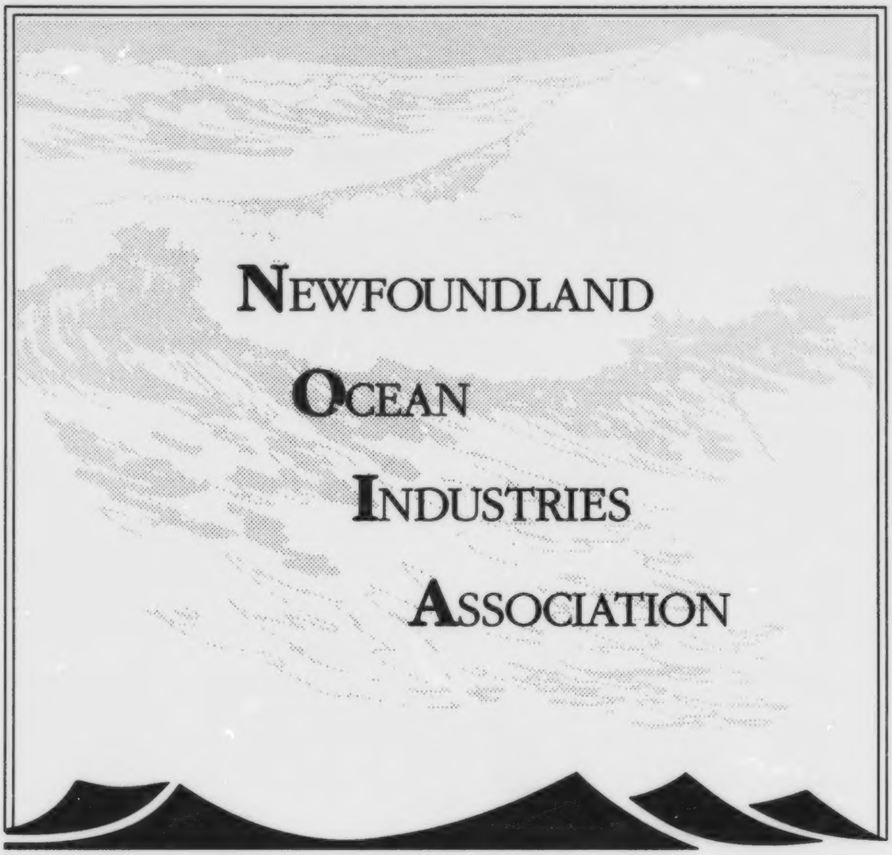
NOIA CONFERENCE '91 PROCEEDINGS


NEWFOUNDLAND
OCEAN
INDUSTRIES
ASSOCIATION

Offshore Newfoundland: The Birth Of An Industry

St. John's, Newfoundland
June 17–19, 1991

Box 44, Atlantic Place • 215 Water St. • St. John's, NF • Canada • A1C 6C9
Telephone: (709) 753-8123 • Facsimile: (709) 753-6010

NOIA
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Offshore Newfoundland: The Birth of an Industry

7th International Offshore
Petroleum Conference

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TABLE OF CONTENTS

PAGE

CONFERENCE CHAIRPERSON'S MESSAGE i

CONFERENCE COMMITTEE ii

NOIA BOARD OF DIRECTORS & STAFF. iii

PROGRAM. iv

CONFERENCE OPENING ADDRESS (The Honourable Dr. Rex Gibbons, Minister of Mines & Energy, Government of Newfoundland & Labrador). 1

CONFERENCE PAPERS:

SESSION I - HIBERNIA UPDATE

- *Hibernia Project Update*
  Derek Owen
  Hibernia Management & Development Company Ltd . 27

- *Hibernia Gravity Base Structure Update*
  Fraser Edison
  NODECO. 52

- *Hibernia Topsides Update*
  L.F. Rolstad
  Newfoundland Offshore Contractors - NOC 83

- *Role of the Certifying Authority*
  David Croston
  Lloyd's Register of Shipping. 128

OPENING LUNCHEON ADDRESS (Bob Kimberlin, President, Hibernia Management & Development Company Ltd). 146

92-03157/

PAGE

SESSION II - INNOVATIVE TECHNOLOGY FOR HIBERNIA

- Remote Sensing Systems for Integrated Offshore Environmental Monitoring
  Pip Rudkin
  Atlantic Airways. 162
- Iceberg Detection Using Microwave Radar
  Joe Ryan
  Sigma Engineering 171
- Long Range Detection of Icebergs and Ships Using Groundwave Radar
  Dr. A.M. Ponsford
  NORDCO Limited. 185
- Design Aspects of the Topsides Unit for the Hibernia Platform
  Derek Langford
  Newfoundland Offshore Contractors - NOC 199
- Unique Technical Aspects Related to the Design of the Hibernia GBS Structure
  Nicolas Parsloe
  NODECO. 214

PAGE

SESSION III - BEYOND HIBERNIA

- *Petroleum Potential of the Sedimentary Basis Offshore Newfoundland: A Framework for Development to the Year 2010*
  Steven M. Millan
  C-CORE. 250

- *Exploration Potential of Offshore Newfoundland & Labrador Outside the Jeanne D'Arc Basin*
  Iain K. Sinclair
  Canada-Newfoundland Offshore Petroleum Board
  CNOPB 268

- *Offshore Newfoundland: Canada's Next Major Oil Producing Area*
  Gary C. Bruce
  Petro-Canada Resources. 298

- *A New Generation of Floating Production Facilities*
  Torbjorn Mehli
  Aker a.s. 314

- *Subsea Production Systems; Past, Present & Offshore Newfoundland; Can Engineering Reduce Costs?*
  Murray H. Chancellor
  J.P. Kenny Offshore Engineering (Canada) Limited 331

CLOSING LUNCHEON ADDRESS (Honourable Jake Epp, Minister, Energy, Mines and Resources, Government of Canada). 371

LIST OF CONFERENCE SPEAKERS & ADDRESSES 376

LIST OF CONFERENCE ATTENDEES & ADDRESSES. 378

NEWFOUNDLAND OCEAN INDUSTRIES ASSOCIATION
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CHAIRPERSON'S MESSAGE

It is with a great deal of pleasure that I write a few words of introduction to the official Proceedings for this year's Conference.

The contents of these Proceedings represent a tremendous amount of effort on behalf of many people.

Firstly, I wish to thank the speakers, who gave so freely of their time, and, more equally important, their knowledge.

Secondly, I want to say thank you to those members of the Conference Committee who worked with us in planning and organizing the Conference.

Thirdly, I want to acknowledge the efforts of the staff of NOIA who put together the organization and administration of this year's Conference so competently and professionally.

Finally, I say thank you to those who attended NOIA Conference '91. We hope we provided you with the quality of Conference that you expected and we look forward to seeing you next year.

Sincerely yours,

Rob Strong

Rob Strong
Conference '91 Chairperson

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Pennecon Limited

Ruth Graham
Newfoundland Ocean Industries Association

Clarence Dwyer
Accord Offshore Ltd.

John Henley
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SUITE 805, 215 WATER STREET
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PROGRAM

7:30 - 8:15 a.m.	**Registration**
8:15 - 8:30 a.m.	**Official Opening** *The Honourable Dr. Rex Gibbons* *Minister of Mines & Energy* *Government of Newfoundland & Labrador*

SESSION I - HIBERNIA UPDATE

8:30 - 9:15 a.m.	**Hibernia Project Update** *Derek Owen* *Hibernia Management & Development Company Ltd.*
9:15 - 10:00 a.m.	**Hibernia Gravity Base Structure Update** *Fraser Edison* *NODECO*
10:00 - 10:30 a.m.	**Coffee Break**
10:30 - 11:15 a.m.	**Hibernia Topsides Update** *L.F. Rolstad* *Newfoundland Offshore Contractors (NOC)*
11:15 - 12:00 p.m.	**Role of the Certifying Authority** *D.J. Croston* *Lloyd's Register of Shipping*
12:00 - 12:30 p.m.	**Panel Discussion with the Day's Speakers** *Moderator: Clar Dwyer* *Accord Offshore Ltd.*
12:30 - 1:00 p.m.	**Cash Bar**
1:00 - 2:00 p.m.	**Opening Luncheon** *Guest Speaker:* *Bob Kimberlin* *President* *Hibernia Management & Development Company Ltd.*

SESSION II - INNOVATIVE TECHNOLOGY FOR HIBERNIA

8:00 - 8:30 a.m.	**Registration**
8:30 - 9:10 a.m.	**Remote Sensing Systems for Integrated Offshore Environmental Monitoring** *Pip Rudkin* *Atlantic Airways*
9:10 - 9:50 a.m.	**Iceberg Detection using Microwave Radar** *Joe Ryan* *Sigma Engineering*
9:50 - 10:30 a.m.	**Long Range Detection of Icebergs and Ships using Groundwave Radar** *Dr. A.M. Ponsford* *NORDCO Limited*
10:30 - 10:50 a.m.	**Coffee Break**
10:50 - 11:25 a.m.	**3D CAD Design Aspects of the Topsides Unit for the Hibernia Platform** *Derek Langford* *Newfoundland Offshore Contractors*
11:25 - 12:00 p.m.	**Unique Technical Aspects related to the Design of the Hibernia GBS Structure** *Nicolas Parsloe* *NODECO*
12:00 - 12:30 p.m.	**Panel Discussion with the Day's Speakers** *Moderator: Sheila Smith* *Ernst & Young*

SESSION III - BEYOND HIBERNIA

8:00 - 8:30	**Registration**
8:30 - 9:10	**Petroleum Potential of the Sedimentary Basins Offshore Newfoundland: A Framework for Development to the Year 2010** *Steven M. Millan* *C-CORE*
9:10 - 9:50	**Exploration Potential of Offshore Newfoundland and Labrador Outside the Jeanne D'Arc Basin** *Iain K. Sinclair* *Canada-Newfoundland Offshore Petroleum Board*
9:50 - 10:30	**Offshore Newfoundland: Canada's Next Major Oil Producing Area** *Gary C. Bruce* *Petro-Canada Resources*
10:30 - 10:50	**Coffee Break**
10:50 - 11:25	**A New Generation of Floating Production Facilities** *Torbjorn Mehli* *AKER a.s. NORWAY*
11:25 - 12:00	**Subsea Production Systems** **Past, Present & Offshore Newfoundland** **Can Engineering Reduce Costs?** *Murray H. Chancellor* *J.P. Kenny Offshore Engineering (Canada) Limited*
12:00 - 12:30	**Panel Discussion with the Day's Speakers** *Moderator: Martin G. Sheppard* *Department of Mines & Energy* *Government of Newfoundland and Labrador*
12:30 - 1:00	**Cash Bar**
1:00 - 2:00	**Closing Luncheon** *Guest Speaker:* *The Hon. Jake Epp, P.C., MP* *Minister* *Energy, Mines and Resources* *Government of Canada*

NOTES FOR THE OPENING ADDRESS TO THE NOIA CONFERENCE '91

By

The Honourable Rex Gibbons

Minister of Mines and Energy

Government of Newfoundland and Labrador

St. John's, NF
1991 06 17

Introduction

Thank you Mr. Chairman, and good morning ladies and gentlemen.

I would like to begin by thanking the Newfoundland Ocean Industries Association for inviting me to open this 7th International Conference. This annual event has gained a reputation as a world-class forum for discussion of offshore oil and gas resources.

Exciting things are happening in the oil and gas industry in this province - positive developments that will assist in the economic development of Newfoundland and Labrador.

The people of Canada, and most certainly the people of Newfoundland and Labrador, have waited a long time for the Hibernia Project to begin and for the benefits of the $5.2 billion pre-production construction expenditures to be reaped.

I'd like to state that Hibernia is **HERE** and Hibernia is **NOW**, and that the benefits of the project are being felt.

The Conference Board of Canada forecasts Newfoundland to lead the nation in economic growth in 1991, and that it will make a significant contribution towards leading Canada out of the current recession. This optimism is also shared by major Canadian banks and financial institutions which point to the fruits of Hibernia as a catalyst for the Province's and Canada's economic growth.

- More about Hibernia, later.

Oil & Gas Policy

A principal goal of the Government of Newfoundland and Labrador is to maximize benefits to residents of the province from the development of oil and gas resources.

The governments of Canada and of Newfoundland and Labrador have invested heavily in the development of onshore infrastructure, R&D capability and technology transfer to provide a foundation on which to build, and a means to provide, long lasting industrial and employment benefits to the province.

Examples include: $95 million to assist in the cost of developing the major offshore construction, fabrication and assembly facility at Bull Arm, Trinity Bay; $36.5 million for the expansion and conversion of the Cow Head Oil Rig Service Center near Marystown to a complex capable of supporting major offshore related steel fabrication; $27 million for the Centre for Earth Resources Research at Memorial University and $11 million in consideration of the Hibernia consortium's commitments to carry out certain design engineering activities in Newfoundland.

Training programs for workers are important in this high technology industry, where emphasis is placed on high standards of quality and quality assurance. In this regard, Government has established an $18 million Career Awards Program and a $21 million Petroleum Technology Training Program.

We continue to position ourselves to avail of the many opportunities arising from offshore hydrocarbon developments.

For example, government continues to encourage joint ventures among Newfoundland firms and other Canadian and foreign firms, and we encourage oil and gas activity in the offshore area by providing information about these resources across Canada and internationally through the media and various conferences and trade shows.

Clearly, the oil and gas industry has a bright future in Newfoundland. Government will continue to put in place progressive policies leading to the orderly development of oil and gas resources with a minimal amount of social and environmental disruption.

We also believe in the importance of offering, to the industry, a stable and predictable regulatory environment in which to operate. We continue our dialogue with the industry on these matters and will continue to consult the industry where significant change is contemplated.

Newfoundland is a good place to do business in the oil and gas sector. We intend to keep it that way.

Offshore Oil & Gas Activity

The Newfoundland offshore encompasses some 160 million hectares, and the total area held by industry under licence is approximately 2.3 million hectares or about 1.4 percent. In addition, exploration rights covering approximately 2.25 million hectares of land south of St. Pierre and Miquelon are currently under an exploration moratorium, pending resolution of a boundary dispute with France.

The Canada-Newfoundland Offshore Petroleum Board (CNOPB), as part of its annual land issuance cycle for the offshore, issued a Call for Bids in February, 1991, for four parcels totalling 520,772 hectares. Three of the parcels are located in the Jeanne D'Arc basin on the Grand Banks, and one parcel is offshore western Newfoundland. This Call for Bids ends September 6, 1991.

Over the 25 year period since the first well was spudded in 1966, 138 wells have been drilled and about 573,000 km of seismic data have been collected. Industry expenditures have totalled approximately $3.7 billion.

Exploratory drilling offshore remained low during 1990, with only one well having been completed. The outlook for 1991 is slightly better as British Petroleum (BP) will drill one well beginning in mid-June and there is also a strong possibility of a second well being drilled by Mobil. The BP well, called BP et al Thorvald P-24, is located about 12 kilometres northwest of the Hibernia field, and the Mobil well will be on a Petro-Canada licence 25 km east of Hibernia. Both of the wells will be drilled by the semisubmersible drilling unit, the Treasure Searcher. In addition, several seismic programs will be conducted this year.

At the present time, a 20,000 kilometre seismic program is being conducted at the Hibernia field location on behalf of the Hibernia Management and Development Company. In the same area, a soil sampling program is also underway.

Onshore Oil & Gas Activity

The Canada-Newfoundland Offshore Petroleum Board awarded 7 exploration licences offshore western Newfoundland during 1990. The geology offshore is a logical extension of that exposed in onshore areas.

The onshore portion of western Newfoundland has long been recognized as an area of petroleum potential. Due to a variety of logistical and geological reasons, very little exploration has occurred in this area.

The Department of Mines and Energy has developed new onshore petroleum regulations for the issuance of petroleum rights in the onshore portion of the Province. These regulations became effective on February 15, 1991. The Regulations create a relatively uncomplicated land tenure system consisting of a licence to explore for petroleum, a permit to drill and a lease to produce petroleum.

On May 29, 1991, as Minister of Mines and Energy, I issued a "Call for Postings", pursuant to section 16 of the onshore petroleum regulations. The Call for Postings, which closes on September 13, 1991, invites all interested parties to formally indicate those lands in the onshore area of the Province that they would like to see made available in a competitive Request for Bids for petroleum exploration permits.

It is anticipated that the response will be sufficient to open a Request for Bids in the Fall of 1991. The level of petroleum exploration is not expected to result in any petroleum boom, but could provide opportunities for local labour, goods and services.

Discovered Resources

The exploratory effort offshore Newfoundland and Labrador has resulted in 20 significant discoveries; 5 on the Labrador Shelf and 15 on the Grand Banks. Discovered recoverable resources, expressed at a 50% probability of occurrence, for offshore Labrador are 4.2 trillion cubic feet of natural gas and 123 million barrels of natural gas liquids. Discovered recoverable resources, expressed at a 50% probability of occurrence, for the northeast Grand Banks region are 1.6 billion barrels of oil, 4.0 trillion cubic feet of natural gas and 237 million barrels of natural gas liquids.

Undiscovered Resources

There are no current estimates of undiscovered resources for the Labrador Shelf, but a 1983 Geological Survey of Canada (GSC) report estimated that 26 trillion cubic feet of natural gas, at an average expectation, remain to be found.

A recent CNOPB/GSC evaluation indicates there should be approximately 3.0 billion barrels of oil remaining to be found in the northeast Grand Banks areas. Recent estimates for other areas of the Continental Margin are unavailable; however, the 1983 GSC report referred to above indicates that an additional 2 billion barrels remain to be discovered.

Hibernia Development

Hibernia is the first in a series of offshore field developments that will provide real and meaningful benefits to the people of this

Province. First production is scheduled to occur in 1996 and the field will be on production for at least 18 years. Hibernia development is based on a fixed concrete platform, 83 development wells, subsea facilities, and three purpose-built shuttle tankers. Average daily oil production of 110,000 barrels of oil per day during the peak production period is projected.

Major activity will occur at Great Mosquito Cove in Bull Arm, Trinity Bay, including construction of the GBS, fabrication of the wellhead supermodule and five topside mounted structures, assembly of the topsides, and mating and hook-up of the completed topsides to the GBS.

Capital expenditures on Hibernia are projected to total approximately $5.2 billion by 1996, with an additional $3.3 billion after production begins. Operating phase expenditures are estimated at about $10 billion for the projected 18-year life of the field.

The Bull Arm site, as well as the Cow Head facilities at Marystown, will provide key industrial infrastructure to support development of the Province's offshore oil resources.

On September 14, 1990, the Government of Canada, the Government of Newfoundland and Labrador, and the four members of the Hibernia consortium signed the agreements marking the beginning of the Hibernia project - the largest conventional oil project undertaken by the oil and gas industry in Canada. These agreements were then placed in escrow to await the legislative and legal requirements necessary to allow the project to proceed. On November 29, 1990, a second signing took place releasing these agreements from escrow making them legally effective and binding.

Also on September 14, 1990, two of the largest contracts for the project were awarded by the Hibernia Management and Development Company signifying that the project was officially under way.

The GBS contract, valued at $1.3 billion, was awarded to Newfoundland Offshore Development Constructors (NODECO), a joint venture group of Doris Engineering, Atlas Construction Inc., Janin General Contractors Ltd., McNamara/Wimpey, and Concrete Products. The scope of this contract includes the Bull Arm site development and the GBS construction.

The second contract, the Engineering Procurement and Project Services Contract (EP/PSC) valued at $360 million, was awarded to Newfoundland Offshore Contractors (NOC), a joint venture group of SNC Group, MONENCO, BFL Consultants Ltd., Brown and Root

International Inc., and AKER Engineering. The scope of this contract includes the engineering of the topsides and the procurement of all major equipment and bulk materials. The contractor is also responsible for assisting the project task force in the overall management of the project.

Since September 14, 1990, in excess of 50 contracts and purchase orders have been awarded, many of which are sub-contracts of the two major awards I mentioned previously. The total value of contracts awarded by HMDC, to date, is estimated to be in the area of $2.7 billion. The total project expenditures, to date, is estimated to be $160 million, with 55% being spent in Newfoundland and 80% being spent within Canada.

On the employment side, a total of 1,360 people were employed with the project as of May 31, 1991, with 523 at Bull Arm and 238 in

St. John's, for a total of 761 people located in Newfoundland and a total of 1,229 people in Canada.

The benefits of this project, however, can be measured in terms of more than expenditures and employment. The innovations conceived from this project will place Newfoundland at the forefront of fixed production platform technology, and with new technologies come opportunities for new skills and business opportunities. These opportunities came as the result of endless hours of negotiation by dedicated officials whose sole purpose was arranging the best agreement possible.

The negotiations leading up to the signing of the Hibernia agreements in September of last year involved the securing of work commitments for Newfoundland and for Canada. In addition, it was the policy of Government to see that work in Newfoundland is distributed beyond that committed to the Avalon Peninsula. To date, this policy has been successful with 65% of those currently employed being from regions off the Avalon Peninsula and the recent awarding of the Permanent Camp contract to Newfoundland Design Homes/ATCO, using facilities in Stephenville, western Newfoundland. Also, the awarding of the Wellhead Module contract early this fall could see substantial amounts of work for Newfoundland as a whole.

The Government of Newfoundland and Labrador is dedicated to ensuring that the commitments negotiated in the Hibernia agreements are obtained and that a maximum transfer of skills and technologies takes place. As such, the Canada-Newfoundland Offshore Petroleum Board (CNOPB) is responsible for monitoring Hibernia contracts and administering the Canada-Newfoundland benefits provisions of the Atlantic Accord. This role involves making certain that Canadian and Newfoundland business interests are looked after and that established guidelines for the preparation and awarding of contracts are followed. Through this monitoring process, the federal and provincial governments are made aware of opportunities where local businesses can participate and receive their piece of the Hibernia pie.

These commitments of work, along with the opportunity for the development of local specialties in offshore trades, fabrication, and engineering will ensure that as other fields are developed, the people and business community of Newfoundland will be better equipped to meet the challenges associated with the establishment of a long-term industry in offshore related technologies.

Government is also committed to seeing that the Hibernia project is carried out with a minimum of disruption and in an environmentally responsible and safe manner.

Therefore, we have witnessed a labour agreement among the employers and relevant unions that should insure labour peace throughout the life of the construction project. This is consistent with Newfoundland's desire to develop a strong reputation for completing offshore oil and gas projects on schedule and within budget.

The developers have been required to file, under relevant legislation, an Environmental Protection Plan for the site development and will be required to adhere to regulations and procedures designed to protect the environment during the production phase.

In accordance with recommendations contained in the Cullen Report into the Piper Alpha disaster, a full safety analysis of the production system will be required, beginning at the design stage.

Other Development Opportunities

(i) Terra Nova Field

Favorable drilling results since 1984 have seen reserve estimates increase from less than 100 million barrels to slightly over 400 million barrels of recoverable oil (at a 50% probability of occurrence).

Petro-Canada, the major operator of the Terra Nova field, completed preliminary engineering studies on development strategies in 1989, and has investigated reserves, mode of development, and the preparations necessary before the submission of a Development Plan to the CNOPB.

Over the last year, officials of the Terra Nova consortium met with provincial government officials and reviewed their plans for Terra Nova development. The Department of Mines and Energy, in conjunction with other affected Departments, has completed a preliminary assessment of the Terra Nova field.

First production from Terra Nova is possible before the end of the decade. However, I must state that it is not government's intention to waver in its resolve to carry out its number one policy respecting this field, or any other field development for that matter; that is, attaining the maximum possible level of industrial and employment benefits for the people of this province, before development proceeds.

(ii) Whiterose Field

The Whiterose structure is presently estimated to contain 178 million barrels of recoverable oil, 1.5 trillion cubic feet of natural gas and 58 million barrels of natural gas liquids. This field has only been analyzed on a preliminary basis and a significant amount of delineation drilling is required to more accurately define the potential reserves. Husky, the designated operator for the field, has stated that this field, lying beneath 124 metres of water, is a candidate for future development using a floating production system.

(iii) Other Prospects

The Hebron/Ben Nevis/West Ben Nevis structural complex is estimated to contain in excess of 200 million barrels of recoverable oil; however, the geological complexity of this area will require further delineation drilling before a more accurate estimate of the potential reserves can be made.

Labrador Shelf resources are dispersed over a wide area; however, the largest field, North Bjarni, contains in excess of 2.2 trillion cubic feet of recoverable natural gas. With technology advancing at such a rapid rate, we are hopeful that industry will be able to overcome the technical difficulties associated with oil and gas development in this area, such as those related to iceberg scouring and sea ice. Realistically, however, we do not forecast development of these resources before the year 2000.

Concluding Remarks

In summary, it is clear that the Province of Newfoundland is gearing up for unprecedented growth in its oil and gas sector. Exploration activity is increasing. The Hibernia project is underway. And I am optimistic that the Terra Nova project and others will follow.

From a Newfoundland perspective, I would like to echo the words of my counterpart with the Government of Canada, the Honourable Jake Epp, Minister of Energy, Mines and Resources, in an address to the Offshore Technology Conference in Houston in

May. His text read; "Canada's eastern offshore is going to be a focus for activity throughout the 1990s ... We believe there are significant petroleum exploration and development opportunities in this region, and we would like to see them exploited."

Having said that, it is with great pleasure that I welcome you to our province and declare this conference officially open.

Thank you.

CONFERENCE PAPERS

SPEAKER : DEREK OWEN

COMPANY : HIBERNIA MANAGEMENT & DEVELOPMENT COMPANY LTD.

LOCATION: ST. JOHN'S, NEWFOUNDLAND

TOPIC : HIBERNIA PROJECT UPDATE

BIOGRAPHY: *After Derek Owen graduated from the University of Nottingham with a Bachelor of Science in Mechanical Engineering in 1962, he worked with a variety of major firms serving the oil and petrochemical industries. At Badger B.V., The hague, he was the Deputy Sub-Contract Manager for the Mobil Wilhelmshaven Project.*

In 1981, he joined Mobil Services Co. Limited as a Senior Associate Engineer in the projects section of MSCL Engineering Department. A few months later, he became the Business Manager for the Stratford `B' offshore project in Norway, where he also acted regularly for the Senior Project Manager.

In 1983, Owen became the Business Manager of the Venture Development Project in Nova Scotia. Three years later, he moved again, this time to Woerth, Germany as Project Manager where he completed two projects within the schedules and budgets assigned.

Currently, he is Hibernia's Project General Manager and is responsible for overall engineering, procurement, and construction of the facilities and to be on schedule and within budget.

Owen is a chartered engineer in the U.K. and a fellow of the Institution of Mechanical Engineers in the U.K.

Presentation to the NOIA Annual Conference

HIBERNIA PROJECT UPDATE

By: Derek Owen,
Hibernia Project General Manager
June 17, 1991

1. Introduction

Thank you Clar. SLIDE #

I have been reminded by the Chairman that it is the duty of the opening speaker to keep everyone awake. 1

I also notice that I am expected to speak to you for 45 minutes.

I believe it was Lord Brabaton who once said in the House of Lords that "if you cannot say what you are going to say in 20 minutes you ought to go away and write a book about it."

Anyway let's get underway.

Good Morning and Welcome.

The turnout at the conference and trade show is very impressive. It certainly demonstrates the high level of interest in offshore Newfoundland. The Agenda is very full of Hibernia items and some very specialized presentations are to follow. These will go into greater detail about some of the things I will touch on today.

What I really want to do is provide you with an update of the project and to some degree set the scene for the other presentations. I will focus on how we at the Hibernia Management & Development Company (Hibernia) will be getting the Hibernia project done.

Whenever you hear anyone from Hibernia discuss the project, you will always hear us emphasize our intent to build a safe, efficient production system. You will also hear us emphasize doing the work on time, within budget, and to the strictest of quality standards. These statements are our commitments.

To achieve these commitments, you need the right mix of people, resources and technology. If you have it, you can pull together a large project like Hibernia, safely, efficiently, on time, within budget and to specification.

SLIDE #

First, a bit of background to the project. Most of you will already be
quite familiar with Hibernia. We are in the first phase of the project
now. This primarily involves detailed engineering, procurement and
construction of the production platform for the Hibernia field. The 2
second phase starts once the platform is completed and installed in
1996, when we will operate the platform to produce the oil reserves in
the field.

When I say "we" I mean the Hibernia Management and Development
Company (or Hibernia), which is an operating company established by
the project owners to cover both these phases. The Hibernia 3
Management and Development Company is made up of four owner
companies - Chevron, Gulf, Mobil and Petro-Canada. It has overall
responsibility for the field development and production.

Since the project agreements were signed last September, it's been full speed ahead on the project, with emphasis in two areas:

1. assembling the people, resources and technology, and
2. getting the detailed engineering and construction underway.

Here is a slide showing the key features of the production system. I'm
sure the main components are very familiar to you. And here is what 4
we have to do:

- Design and build the GBS
- Design and build the Topsides modules, which have come to be known as "Super" modules. 5
- Assemble the completed Topsides unit, which will be a fully-integrated deck. 6
- Mate the GBS to the Topsides 7
- Set the platform in place
- Design and build the Offshore Loading Systems, subsea systems and tankers. 8

The project will be unique in that it will be the first time super module technology has ever been used in this manner for Topsides construction and assembly.

SLIDE #

Similar structures have been built before in Europe - similar in that they use GBS technology. But this is Canada's first GBS type platform and it will bring together significant Canadian, Newfoundland and international expertise. Indeed, major pieces of the work are already taking place in Newfoundland. 9

Much of the Newfoundland-based work is in Great Mosquito Cove and Bull Arm, on the northeast coast. This is a greenfield site. Many activities will take place here - GBS construction, Topsides assembly, GBS-to-Topsides mating and fabrication of one Topsides "Super" module and five Topside-mounted structures. The other four Topsides modules and three Topside mounted structures will be built elsewhere in Canada or the world. Dick Rolstad of NOC will be covering the Topsides engineering in much greater detail later in the agenda. 10 11

Here are some pictures of the Bull Arm Site Development. The work currently underway involves dredging and drydock construction in Great Mosquito Cove, as well as building quays, roads, accomodation camps, and installing ulitities. You can see that we have made significant progress since last September. For example, nearly 11 kilometres of roads have been completed. The initial phase of camp construction has been completed and 400 beds are available. And as of a few days ago, nearly 200,000 cubic metres of rock had been moved to build the berm at the drydock site. 12 13 14

These visuals give only a hint of what this project involves, but you can see that it is truly an impressive project. To meet the challenge, we are bringing some innovative approaches, not only to the engineering and construction of the platform, but also to the management of the project.

2. Management Approach

SLIDE #

Let me tell you a bit about how we are working to manage this project efficiently. In the history of North Sea projects similar to Hibernia, the general practice has been to use the resources of one major oil company to act as operator to manage the project. 15

For Hibernia however, the owners decided to do it differently. Because the project is so large and requires a diversity of skills, it would have drained the resources of any one of the companies who could have acted as operator. So the owners decided to pool resources and create a single new company to manage the project. This is how the Hibernia Company came to be.

This new team of individuals brings together the technical and personnel resources of all the owner companies - technical experts seconded from Chevron, Gulf, Mobil and Petro-Canada. And it adds to the expertise and experience of a variety of specialists directly-hired to the project and the company.

So it is a new company, but one built on a solid foundation of experience and expertise derived from many diverse and challenging energy projects. It is a company with a very distinct mission: to develop and produce the Hibernia field. 16

We plan to accomplish our mission by:

- building on the strengths of our people and the community;
- acting with respect for safety and the environment;
- and applying progressive leadership, sound management and advanced technology.

It is a big job. Building the Hibernia platform in 6 years requires a lot of human and technical resources; and it requires a coordinated effort. It is in fact, such a large project that there is only one way to manage it and that is to break it down into component pieces. Each major piece of the project has been assigned to its own team of experts who are responsible for managing it. Essentially, the members of each Project Team has assumed "ownership", if you will, of their piece of the project. Each team works as a unit, carefully managing and controlling 17 its piece of the project. And of course, each team also works with the other teams to ensure that, at the end of the project, each piece comes together with the others, as it should.

In the early stages of the project, we are devoting a great deal of effort to team building. Across the Hibernia organization and main contractors I suppose there must have been approaching 20 or so team building sessions. While the term "team building" may mean different 18 things to different people, at Hibernia it means developing a clear mission and common goals, understanding each other, promoting clear, straightforward communications, and encouraging everyone to perform to their maximum potential. Team building is a real challenge - not only because of the size of the project, but also because we are building a new and very special organization at the same time that we are starting a very demanding job. The men and women at Hibernia are drawn from different corporate environments. We have different experiences and different ways of doing things. Our first challenge therefore, is to ensure that we are pulling together.

The same is true for the two major contractors currently on the job. 19 These are NODECO, who have the GBS Engineering and Construction Contract, and NOC, who have the Topsides Engineering, Procurement and 20 Project Services Contract. Each of these companies is a joint venture. Each consists of people drawn from several individual companies, some Canadian and some European. Their challenge, like ours, is to get their people pulling together - and pulling with us. This means having common goals and a common approach.

In explaining the management team structures, I will also show how the contractors link up with us, and how their teams interface with ours.

Let's start by looking at our company, Hibernia. As I have pointed out, 21 the Company is responsible for operating the project - from initial design to ongoing production operations. We do so on behalf of the four owner companies. As Project General Manager, I lead the Project 22 Managment Team, and I am responsible to ensure that the various components of the work are carried out, from the start of pre-engineering to platform installation on the field.

SLIDE #

These various major components are the responsibility of several individual project teams. As the chart shows, there is one for the GBS, one for the Topsides, and later, there will also be an OLS/Pipelines team. There is also a Business Group which serves the entire project.

Essentially, each of these major components is a project unto itself, and the team makeup reflects this. So if you look at the GBS Team, it 23
has a manager, Terry Lloyd. On his team, he has a Business Manager, a Construction Manager and an Engineering Manager. The GBS main contractor, NODECO, has a team of its own which is more or less parallel to Terry Lloyd's GBS Project Team. Using engineering as an example, this means Hibernia's and NODECO's GBS Engineering Managers manage their functions and they also communicate and work together.

The same is basically true for Topsides Manager Jacques Brabant's Team. When you compare NOC's Topsides team with Hibernia's, you will 24
see the same parallels. Hibernia has a Topsides Engineering Manager, and so does NOC. Hibernia has a Topsides Modules Manager, and NOC has a manager responsible for modules.

Remember however, that NOC is not responsible for construction of the Topsides modules. The Hibernia Project Team, through the Modules Manager, will directly manage the module fabrication sites. NOC, via their Project Services Contract, will provide staff to assist us in managing these sites. Overall, it is a complex management structure which reflects the requirements of the project.

A great many people are already working on their part of this project. More than 1350 people were assigned to the project at the end of May; 25
128 of them are employed by the Hibernia Company, and are spread among three offices in St. John's, the main Topsides office in Montreal and the GBS office in Paris, France. NOC had about 490 people on stream handling two functions -Topsides Engineering and Procurement, and Project Services - from the main office in Montreal and a satellite office in St. John's. And NODECO had 736 people working for it, either directly or through sub-contractors, in St. John's, Bull Arm and Paris. As you can see the mobilization of people at 6 different locations has proceeded quickly with over 1350 people from Hibernia, the contractors and sub-contractors now involved.

3. Contracting and Procurement Strategy

SLIDE #

I now want to spend a few moments talking about our contracting 26
strategy for the project. Hibernia is no different from many large
industrial projects in that it will make extensive use of contracted
services. To successfully break the project down into manageable
pieces, and to mobilize enough of the necessary resources to do the job,
you have to contract out extensively. The contractors and sometimes
hundreds of sub-contractors then become an extension of your project
team, each with their own responsibilities, and each relied upon to get
their work done properly and on time.

Hibernia's contracting strategy is based first and foremost on getting
the right people to do the job. The right contractors are those who have
the appropriate experience and expertise, and the facilities or
equipment required, as the case may be. We always request 27
competitive bids for services. It is in our interest as the operator to
choose those contractors who can provide the best combination of
price, quality, delivery and Canada/Newfoundland benefits. In the
project agreements, we have recognized the high level of Canadian
interest in the Project, and made a number of very specific
commitments related to engineering and construction in Canada and
Newfoundland.

These commitments, in summary, are: 28

- Design engineering for the flare boom, helideck and the accomodations portion of the living quarters module;
- Design engineering for the subsea lines to the Offshore Loading facilities;
- At least 50 per cent of the GBS design engineering.

These commitments are for design engineering work in Newfoundland. The total commitment for project management and engineering design in Canada is between 80 and 95 per cent.

On the construction side, the GBS, the M20 Wellhead module, the
Helideck, the Air Control module, the Main and Auxiliary Lifeboat 29
Stations and the Flare Boom will be built in Newfoundland at Bull Arm.
The two Drilling Derricks will be built in Canada, and we have also 30

committed to building the GBS Decks and Preassemblies, and the
Driller's Office and Piperack Topside-mounted structures in Canada - if
there are at least three qualified Canadian bidders. The remainder of 31
the super modules will be open to competitive bidding internationally.
Our commitment in this context is to provide a full and fair opportunity
to qualified firms to bid for work.

Perhaps it would be useful to walk through the process we follow for large contracts to show how this principle is applied in practice. Our normal practice is to :

- Prequalify a list of potential bidders, based on our knowledge of the industry and on information supplied by companies and joint ventures interested in the work. Our objective here is to ensure that we only include bidders with the expertise, experience, facilities and capacity to do the job. This process ensures that the bids we ultimately receive will be valid and competitive. 32

- Once we have a list of prequalified bidders, we send questionnaires to those companies. It comes back providing us with very detailed information on the companies, their facilities and expertise, their experience and their work capacity. Based on this information, we are then able to develop a final bid list to whom we send a Request for Proposals. The bid list normally includes a minimum of three and a maximum of six companies.

As an example, this process was used to select the bidders for the M20
Wellhead Module, to be fabricated at Bull Arm. The companies who 33
received Requests for Proposals on May 21, 1991 were:

- Topsides Contractors of Newfoundland
- PCL - Aker Stord - Steen - Becker
- Trinity Bay Offshore Contractors.

They are due to submit their bids on July 9, 1991. We plan to award the contract in September of this year.

For the procurement of equipment, materials and services for the Topsides - which is NOC's responsbility - NOC will also follow a similar prequalification process. For the GBS, NODECO will do likewise. Like NODECO, the Topsides Module Contractors will likely issue a number of sub-contracts. NODECO, for example, has already issued about 20 major sub-contracts.

As a final point, we have also taken steps to ensure that business people in Canada are aware of the major contracts and procurement packages as they come up for bid, largely through notices in major newspapers in Newfoundland and the rest of Canada.

In this effort, once again, our objective is to give Canadian firms a full and fair opportunity to bid.

4. Role of Technology in Project Management

Although we consider people to be the key to achieving our project mission, we are also very proud to talk about the way the men and women of Hibernia are mobilizing the latest technology to make the management of the Hibernia project more efficient. It is interesting to note that the technology I am talking about is fundamentally communications technology. This is most appropriate, since good communication is at the heart of team building and helping people to work efficiently together. 34

MPMS

One of the major systems that we have adopted for the management of the project is the Monenco Project Management System, or MPMS, which is soon to be re-named the Hibernia Project Management System (HPMS). This technology is available to us through NOC, whose joint venture includes Monenco. 35

HPMS is a central project data base, fully-integrated through the use of a project coding structure designed specifically for the Hibernia project. It is a relational data base using single point data entry. The integration of the data through project coding allows us to manage engineering, procurement and construction through one common system. It assists us in managing all the functions - from cost engineering through planning, purchasing, material control, invoice control, project engineering and construction. Here is a typical flow chart. You will notice that the communications flow is not at all linear or one-way, but is very interactive. 36

What makes HPMS unique however, is not so much its functional characteristics, but its scope. With it, we collect all data at a single entry point, and we do it only once. Thereafter, every bit of new information entered updates the original data. And the database can be used by anyone, anywhere, who is linked into to the project system.

Not only does this system serve the Project Teams within Hibernia, but it can also be tied into the project control systems of contractors. For example, NOC - in providing Topsides engineering, procurement and project support - is a user of the database. The HPMS currently communicates among the various Hibernia/NOC Project Team offices in St. John's, and the Montreal Topsides Office. It will also interface with the GBS Team and NODECO, who use different basic systems, but who are able to connect with HPMS for overall control and reporting. Down the road, HPMS will also be tied into the various module fabrication contractors to extend the project management capacity right into those yards.

CAD

Another innovation for this project will be an extensive use of 3D CAD, both for the engineering of the Topsides, and also for some of the design of the piping and utility systems in the GBS. Derek Langford of NOC will be providing a detailed presentation on this subject tomorrow, so I won't steal his thunder. However, I will say that we are well along in developing the 3D computer model that will serve as the basis of the CAD Program. It will greatly enhance the efficiency and quality of the Topsides and GBS engineering. 37

The 3D model for the Topsides is currently being developed in Montreal. As well, RDS Engineering of St. John's has a contract with NODECO to provide 3D CAD services for the GBS.

There are a number of obvious advantages of 3D CAD for Hibernia. One is that the computer model is a data base. This makes it relatively easy to store, access and update information. It also eliminates the need for thousands of hardcopy engineering drawings. And because it is in 3D, we can readily see the results of the engineering as it evolves. Two, it is also linked to a variety of locations where engineering and construction are taking place. Three, in building the model, the 3D CAD capacity allows us to do extensive interference checking, because the 3D CAD software is designed to make the platform "clash-free". 3D CAD is not new to us, of course, but its use on the Hibernia project is one of the most significant applications in Canada to date.

Document Imaging

SLIDE #

38

We are looking to acquire another bit of technology that we believe will save time and money, and make the job more efficient for our people. This is document imaging. This technology helps us in managing the project by allowing us to electronically enter new hard copy data - such as reports and contractors' engineering drawings - into the management system.

Basically it is document scanning, storage and retrieval technology. It creates data files that can, like the other databases, be accessed on P.C.'s from a variety of locations where project engineering or construction may be going on.

As time goes on, we will incorporate improvements and developments in technology that will no doubt enhance by several more degrees, the overall efficiency of project management, and help us meet our targets.

5. Labour and Training

SLIDE #

I now want to focus on another very important aspect of doing the job and that is Labour and Training. The fabrication and construction of the platform will involve some very skilled and demanding labour. A significant amount of fabrication and construction will take place at Bull Arm, and we are very encouraged by the steps that the Oil Development Council (a Council of 14 Building Trade Unions) and the Hibernia Employers' Association have taken to ensure that the site work progresses smoothly. 39

In signing the Project Site Labour Agreement last July, the Oil Development Council and The Hibernia Employers' Association made a crucial commitment that ensures, firstly that skilled and qualified people will work on the project, and secondly, that the progress of the work at the site will not be held up in any way. It is a very progressive Site Labour Agreement, and we are very proud of the fact that it was in place three months before the project officially started. 40

At peak, about 3000 people will be working at the Bull Arm site. At the present time, a sufficient number of people with the required skills are not immediately available to do all of the work required at Bull Arm. Some areas of potential shortage include, for example, scaffolders and rebar workers. However, we at Hibernia, along with representatives of the major contractors, have been working closely with training institutions, government and the ODC member unions to identify and rectify some of the shortfalls. We have been encouraged by the initative shown by all parties in this respect. Both the provincial and federal governments have allocated funds for training and several million dollars have been invested in new instruction programs, and in the training of instructors.

But we are not there yet, and more work still has to be done in this important area of training. The problems are being addressed, and I am sure that we will maximize employment benefits for workers in Newfoundland, and of course, have the right people for the job. This will be key to our success in meeting our mission.

SLIDE #

6. Quality, Safety, Environmental Management

There are a number of other issues relevant to sound management of
the project that deserve special mention. These are quality standards, 41
safe operations and environmental management, all of which will be
key to everything we will be doing in engineering and construction. It
is of course, easy enough to speak these words. But as one of my
colleagues in Hibernia's safety department is quick to point out, the
words are meaningless without a true commitment. At Hibernia, we
have such a commitment, and we demand a similar commitment of our
contractors and sub-contractors.

I want to take a moment to explain how we put that commitment to work, and I'll start with Quality Assurance. Hibernia's policy with regard to Quality Assurance is best represented by the Statement of Policy and Authority contained in the Hibernia Project QA Plan. In short, it commits Hibernia to building state-of-the art facilities which are safe, environmentally sound and economic, through the application of QA principles and practices as outlined in the Project QA Plan.

The Hibernia Project QA Plan further states that the responsibility for 42
achieving specified requirements (i.e. Quality) rests with the
individuals performing the work, while the responsibility for verifying
that the specified requirements have been met is that of the QA
function. This independence of responsibility - achieving results
versus verifying results - is a cornerstone of HMDC's QA policy and is
passed on to project contractors and suppliers through the 43
implementation of national Quality Standards such as CSA Z299.

What this means in practice, is that Quality will be built into everything we do. With the introduction of the Canadian Oil and Gas Installation Regulations in August 1990, the application of QA programs also became a statutory requirement. For Hibernia, the statutory QA requirement became CSA Z299 Quality Standards.

Virtually all project contractors and suppliers who provide goods or services to the permanent production installation will be required to prepare QA programs which meet the requirements of one of the Quality categories of Z299. CSA Z299 has four categories, ranging from category 1 (most stringent) to category 4 (least stringent).

SLIDE #

NOC and NODECO are currently developing CSA Z299 category 1 QA
programs. Hibernia will monitor the QA performance of project
contractors and suppliers through a network of QA professionals 44
assigned to the various project teams.

Monitoring contractor QA performance is accomplished by QA audit, surveillance and inspection.

With regard to Certification, we have awarded a contract to Lloyd's Register of Shipping as Certifying Authority. Lloyd's Project Manager, Dave Croston, is currently resident in our Montreal Topsides Office. Design appraisal of the GBS and Topsides designs are currently under way. Lloyd's activities will increase during the equipment manufacture and module construction phases of the project. Coordination of Certifying Authority activities is accomplished through the Hibernia QA group.

In summary, our approach is a pretty straightforward one of checks and balances. That is, we achieve results through planned, prescribed methods and then independently verify those results. It is all very formal in structure, organization and reporting. There is however, a not so obvious element to the HMDC approach to quality, which is of course team building. The application of team building by major project contractors can influence quality. Team building has the potential to influence people to do the right thing, the first time - even when no one is looking.

Safety

The same is true with regard to safety. Safe operations are a function
of people working together, communicating, and taking leadership 45
responsibility. Our approach to safety is that, like quality, it must be
automatic. It must be built into everything we do. It should be second
nature. A quality job is a safe job. In safety, our focus is on
prevention.

We observe basic principles of safety management and we require that
our contractors will take a similar approach. Our philosophy on safety 46
can be summarized in three basic statements:

SLIDE #

- Safety is to be integrated into everything we do;
- Safety is to be considered along with technical, cost, quality and any other considerations;
- Safety is everyone's business.

Of course, to ensure that all operations are safe, we have a 47
comprehensive Safety Program. Among other things, it identifies:

1. management's leadership role;
2. the measures and systems to ensure that properly qualified and trained persons are selected for the work required;
3. the standards and procedures which define the safety criteria for platform design and operations;
4. the safety features to be built into the platform;
5. the means by which we audit to identify hazards; 48
6. the organization and procedures needed to respond to emergency situations;
7. investigation and follow-up procedures required to prevent recurrence of incidents;
8. occupational health programs.

These aspects of safety planning are relevant not only to the Hibernia Company, but also to the main contractors and their sub-contractors. Everyone is expected to operate with safety at the top of mind.

I also want to emphasize that we have a rigourous program to build
safety into the design of facilities. Safety is integral to the 49
engineering. The independent Certifying Authority also reviews the
design for safety. And of course, we observe Regulatory Authority
guidance from the Canada - Newfoundland Offshore Petroleum Board.

Environmental Management

Finally, in this same vein, I want to review our commitment to 50
environmental management. In our mission statement, we have pledged
to act with respect for the environment. The design of the platform,
the conditions under which the Bull Arm site is operated, and the
subsequent design operating criteria for the platform during production 51
operations reflect our commitment to environmental management.
This commitment is founded on three principles:

SLIDE #

- Construction activities in Bull Arm will be conducted in a way which protects the biophysical, socio-economic and fisheries aspects of the environment;
- Hibernia and all contractors/sub-contractors will comply with all environmental laws and regulations;
- Hibernia will co-operate with industry, government and the public to identify ways to improve environmental management.

Perhaps the best way to highlight how we are putting our commitment into practice is to review the Environmental Protection Plan for the Bull Arm site, which is to be implemented by NODECO and also later by the Topsides contractor. Among its provisions are a number of measures designed to ensure that the fishery and the marine environment in Bull Arm and Great Mosquito Cove are adequately protected. The major provisions of the EPP for the Bull Arm site are: 52

- an environmental Quality Assurance/Quality Control program which ensures that engineering and construction activities take account of environmental considerations before work goes ahead;

- environmental orientation and training for every person working on the construction site in Bull Arm;

- a full-time community liaison person for Bull Arm and the surrounding area;

- a full-time fisheries liaison person at the construction site.

To monitor implementation of the EPP, we at Hibernia have two full-time people at the site. Their role is to ensure that the provisions of the EPP are met.

This is our commitment, and it is one that we take very seriously. We also expect anyone who is involved in the project to take it seriously. Environmental management, like safety, design, quality, schedule and cost, are priorities of the project, and ultimately, they are everyone's responsibiltity.

8. Conclusion

SLIDE #

By way of conclusion, I want to take a brief look at the challenge ahead. Since the beginning of the project 10 months ago, we have made some real progress against our project objectives. The schedule has been tight, and continues to be. But the major deadlines have been met, and we look forward to the work ahead. –

This schedule shows all items that we have to complete over the next 5 years. Some of the major ones coming up are: 53

October 1991
- Start construction of Module Fabrication Facilities at Bull Arm

April 1992
- Start fabrication of all Topsides Modules

Also April 1992
- Drydock completion and start of GBS construction

April 1994
- Begin module assembly and hook-up

March 1995
- Begin mating of the GBS and Topsides

August 1995
- Tow out to production site

April 1996
- Begin development drilling

October 1996
- Begin production

Meeting these deadlines will be a challenge, not only to the companies involved, and their employees, but also to the people of Newfoundland and the people of Canada. As the operator charged with the responsiblility to develop the field, the Hibernia Company's primary obligation is to ensure that the project is managed the right way. 54

Doing it right means managing the construction and operation of the platform efficiently with due regard for all of the things I have talked about - quality, safety and the environment, in addition to the normal technical, schedule and cost considerations. It means using the best minds, the best hands and the best technology to build a system that meets all requirements.

But doing it right also takes into account the legitimate desire of Canadians and Newfoundlanders to benefit from the project. That is why the Hibernia Company is committed to meeting the industrial benefits targets that I outlined earlier.

I am pleased to report that we are doing very well in meeting those targets. Up to the end of May, 1991, for example, actual expenditures by the Hibernia Company were $170 million. Since the start of the project, our typical Newfoundland content on these expenditures has been more than 50%, and our total Canadian content has been in the range of 80%.

In terms of employment, we have achieved 80% Canadian content, with the rest consisting of the necessary international expertise. This of course, translates into work for people - good work on an interesting project that is breaking new ground for Canada.

It is a project that is driven by people. Hibernia and the contractors assigned to the project are not simply companies. They are teams of people who have been asked - and who have agreed - to work together on a project that promises to be very challenging.

They are the means by which Hibernia will be a project that Canada and Newfoundland can be proud of.

To close I suppose it would be gratifying if all the men and women involved with the project could eventually make the same statement as was made by Joey Smallwood when he said "I love this job, I love it to death, I love every waking minute of it."

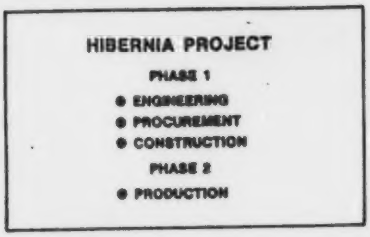
Thank-you.

- End -

1

PROJECT UPDATE

2



HIBERNIA PROJECT

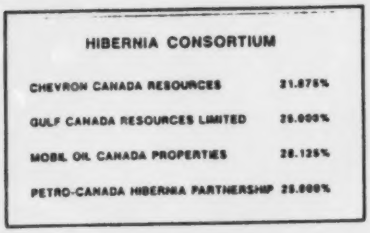
PHASE 1

- ENGINEERING
- PROCUREMENT
- CONSTRUCTION

PHASE 2

- PRODUCTION

3



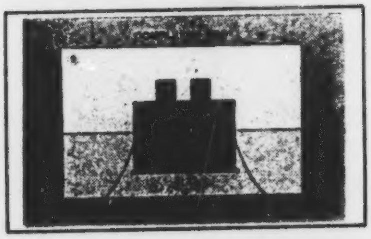
HIBERNIA CONSORTIUM

CHEVRON CANADA RESOURCES	21.875%
GULF CANADA RESOURCES LIMITED	25.000%
MOBIL OIL CANADA PROPERTIES	28.125%
PETRO-CANADA HIBERNIA PARTNERSHIP	25.000%

4

HIBERNIA PRODUCTION SYSTEM COMPONENTS

5



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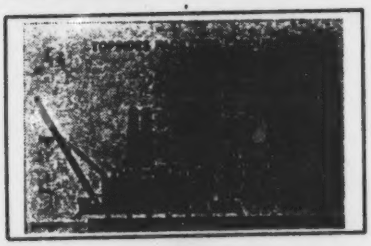

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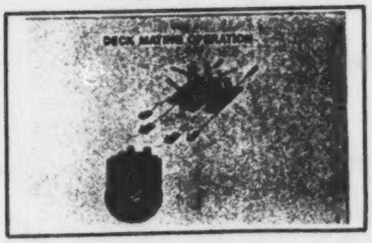
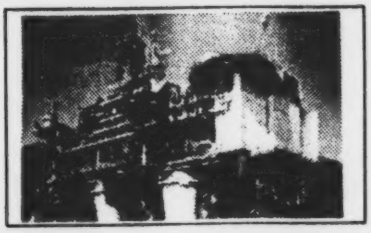


DECK MATING OPERATION

8

9



10

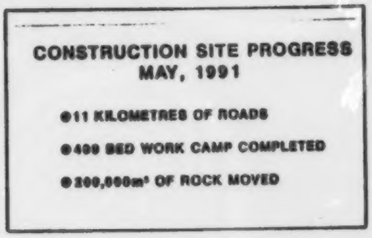
HIBERNIA LOCATION MAP

11

12

13

14



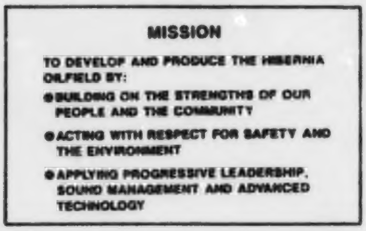
CONSTRUCTION SITE PROGRESS
MAY, 1991

- 11 KILOMETRES OF ROADS
- 400 BED WORK CAMP COMPLETED
- 200,000m³ OF ROCK MOVED

15

PROJECT MANAGEMENT APPROACH

16

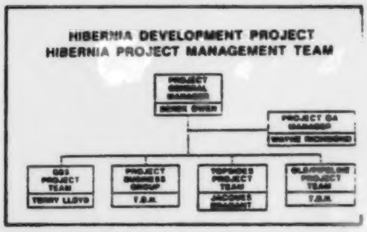


MISSION

TO DEVELOP AND PRODUCE THE HIBERNIA OILFIELD BY:

- BUILDING ON THE STRENGTHS OF OUR PEOPLE AND THE COMMUNITY
- ACTING WITH RESPECT FOR SAFETY AND THE ENVIRONMENT
- APPLYING PROGRESSIVE LEADERSHIP, SOUND MANAGEMENT AND ADVANCED TECHNOLOGY

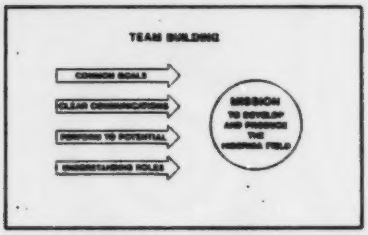
17



HIBERNIA DEVELOPMENT PROJECT
HIBERNIA PROJECT MANAGEMENT TEAM

PROJECT GENERAL MANAGER – DEREK OWEN
PROJECT QA MANAGER – [illegible]
GBS PROJECT TEAM – TERRY LLOYD
PROJECT BUSINESS GROUP – T.B.A.
TOPSIDES PROJECT TEAM – JACQUES [illegible]
OLS/PIPELINE PROJECT TEAM – T.B.A.

18

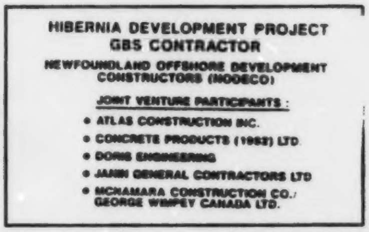


TEAM BUILDING

COMMON GOALS
CLEAR COMMUNICATIONS
PERFORM TO POTENTIAL
UNDERSTANDING ROLES

MISSION
TO DEVELOP AND PRODUCE THE HIBERNIA FIELD

19



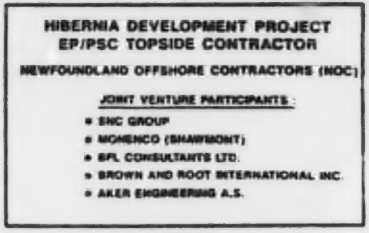
HIBERNIA DEVELOPMENT PROJECT
GBS CONTRACTOR

NEWFOUNDLAND OFFSHORE DEVELOPMENT CONSTRUCTORS (NODECO)

JOINT VENTURE PARTICIPANTS :

- ATLAS CONSTRUCTION INC.
- CONCRETE PRODUCTS (1982) LTD.
- DORIS ENGINEERING
- JANIN GENERAL CONTRACTORS LTD
- MCNAMARA CONSTRUCTION CO./ GEORGE WIMPEY CANADA LTD.

20



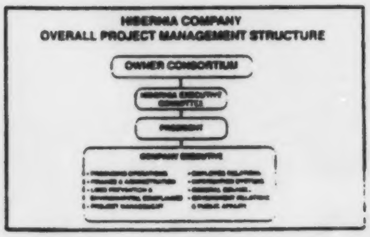
HIBERNIA DEVELOPMENT PROJECT
EP/PSC TOPSIDE CONTRACTOR

NEWFOUNDLAND OFFSHORE CONTRACTORS (NOC)

JOINT VENTURE PARTICIPANTS :

- SNC GROUP
- MONENCO (SHAWMONT)
- BPL CONSULTANTS LTD.
- BROWN AND ROOT INTERNATIONAL INC.
- AKER ENGINEERING A.S.

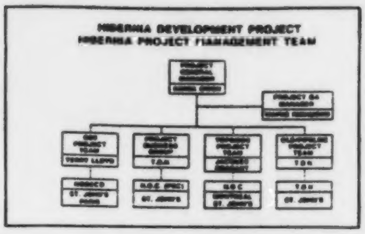
21



HIBERNIA COMPANY
OVERALL PROJECT MANAGEMENT STRUCTURE

OWNER CONSORTIUM
HIBERNIA EXECUTIVE COMMITTEE
PRESIDENT
COMPANY EXECUTIVE

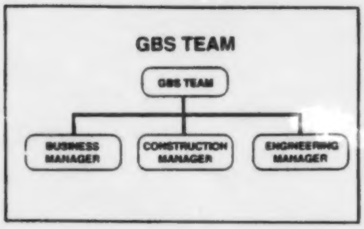
22



HIBERNIA DEVELOPMENT PROJECT
HIBERNIA PROJECT MANAGEMENT TEAM

PROJECT GENERAL MANAGER
PROJECT QA MANAGER
GBS PROJECT TEAM – TERRY LLOYD – NODECO – ST. JOHN'S PARIS
PROJECT BUSINESS GROUP – T.B.A. – N.O.C. (PSC) – ST. JOHN'S
TOPSIDES PROJECT TEAM – N.O.C – MONTREAL ST. JOHN'S
OLS/PIPELINE PROJECT TEAM – T.B.A. – T.B.A. – ST. JOHN'S

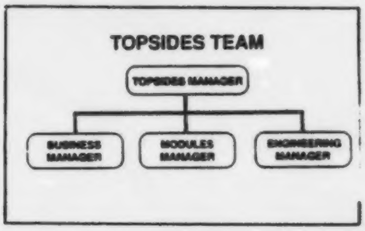
23



GBS TEAM

GBS TEAM
BUSINESS MANAGER
CONSTRUCTION MANAGER
ENGINEERING MANAGER

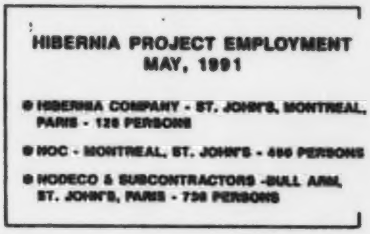
24



TOPSIDES TEAM

TOPSIDES MANAGER
BUSINESS MANAGER
MODULES MANAGER
ENGINEERING MANAGER

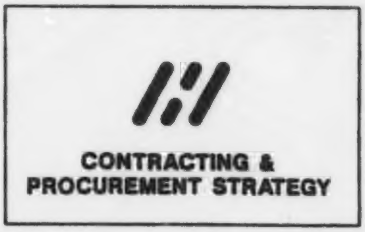
25



HIBERNIA PROJECT EMPLOYMENT
MAY, 1991

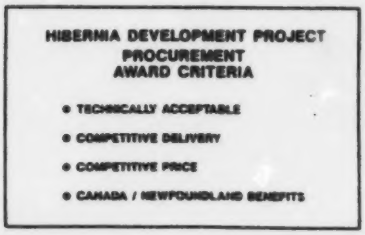
- HIBERNIA COMPANY - ST. JOHN'S, MONTREAL, PARIS - 126 PERSONS
- NOC - MONTREAL, ST. JOHN'S - 496 PERSONS
- NODECO & SUBCONTRACTORS -BULL ARM, ST. JOHN'S, PARIS - 736 PERSONS

26



CONTRACTING & PROCUREMENT STRATEGY

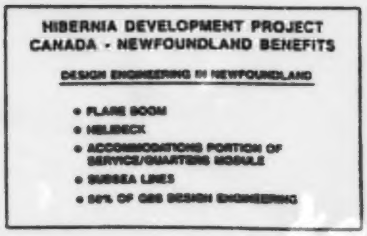
27



HIBERNIA DEVELOPMENT PROJECT
PROCUREMENT
AWARD CRITERIA

- TECHNICALLY ACCEPTABLE
- COMPETITIVE DELIVERY
- COMPETITIVE PRICE
- CANADA / NEWFOUNDLAND BENEFITS

28



HIBERNIA DEVELOPMENT PROJECT
CANADA - NEWFOUNDLAND BENEFITS

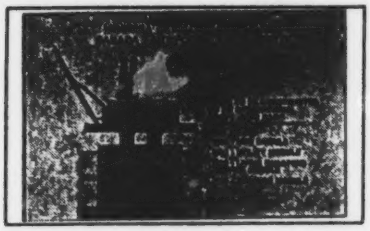
DESIGN ENGINEERING IN NEWFOUNDLAND

- FLARE BOOM
- HELIDECK
- ACCOMMODATIONS PORTION OF SERVICE/QUARTERS MODULE
- SUBSEA LINES
- 50% OF GBS DESIGN ENGINEERING

29

30

31



32

HIBERNIA DEVELOPMENT PROJECT
FABRICATION OF MODULES
PREQUALIFICATION

- TECHNICAL CAPABILITY
- MANAGEMENT / SYSTEMS CAPABILITY
- FABRICATION YARD CAPACITY
- PROVEN TRACK RECORD
- FINANCIAL STABILITY

33

M20 WELLHEAD MODULE
APPROVED BIDDERS

- TOPSIDES CONTRACTORS OF NEWFOUNDLAND
- PCL - AKER STORD - STEEN - BECKER
- TRINITY BAY OFFSHORE CONTRACTORS

34

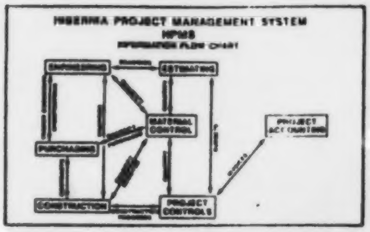
ROLE OF TECHNOLOGY

35

HIBERNIA PROJECT MANAGEMENT SYSTEM
HPMS

- CENTRAL PROJECT DATA BASE
- FULLY-INTEGRATED THROUGH CODING STRUCTURES
- SINGLE POINT DATA ENTRY
- MANAGE ENGINEERING, PROCUREMENT & CONSTRUCTION

36



HIBERNIA PROJECT MANAGEMENT SYSTEM
HPMS
INFORMATION FLOW CHART

ENGINEERING
ESTIMATING
MATERIAL CONTROL
PROJECT ACCOUNTING
PURCHASING
CONSTRUCTION
PROJECT CONTROLS

37

38

39

LABOUR AND TRAINING

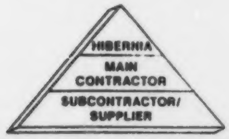
40

41

QUALITY

42

QA RESPONSIBILITIES



HIBERNIA
MAIN CONTRACTOR
SUBCONTRACTOR/ SUPPLIER

MONITOR PROGRAM EFFECTIVENESS

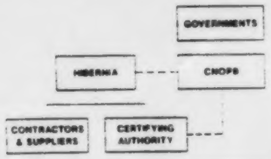
43

QA REQUIREMENTS

- CSA Z299

44

QA/QC REPORTING RELATIONSHIPS



45

SAFETY

46

HIBERNIA SAFETY PHILOSOPHY

- SAFETY - INTEGRATED INTO EVERYTHING WE DO
- SAFETY - CONSIDERED ON AN EQUAL BASIS WITH TECHNICAL, COST & QUALITY
- SAFETY - EVERYONE'S BUSINESS

47

SAFETY PROGRAM

IDENTIFIES:

- MANAGEMENTS' LEADERSHIP ROLE
- MEASURES TO ENSURE USE OF QUALIFIED PERSONS
- STANDARDS & PROCEDURES WHICH DEFINE THE PLATFORM DESIGN SAFETY CRITERIA
- PLATFORM SAFETY

48

SAFETY PROGRAM (CONT')

IDENTIFIES:

- SAFETY AUDIT METHODS
- EMERGENCY RESPONSE
- INCIDENT INVESTIGATION & FOLLOW-UP
- OCCUPATIONAL HEALTH PROGRAMS

49

SAFETY BUILT INTO PLATFORM DESIGN

50

ENVIRONMENTAL MANAGEMENT

51

ENVIRONMENTAL MANAGEMENT PRINCIPLES

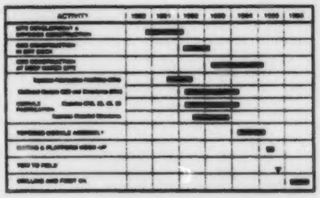
- CONSTRUCTION SENSITIVE TO BIOPHYSICAL, SOCIO-ECONOMIC & FISHERIES
- ALL PROJECT WORK TO COMPLY WITH ALL LAWS & REGULATIONS
- FULL COOPERATION WITH INDUSTRY, GOVERNMENT & THE PUBLIC

52

ENVIRONMENTAL PROTECTION PLAN KEY POINTS

- IMPLEMENT AN ENVIRONMENTAL QA/QC PROGRAM
- PROVIDE ENVIRONMENTAL ORIENTATION/TRAINING
- ESTABLISH COMMUNITY CONSULTATION
- PROVIDE FOR FULL TIME FISHERIES LIAISON

53



54

SPEAKER : ***FRASER EDISON***

COMPANY : ***NEWFOUNDLAND OFFSHORE DEVELOPMENT CORPORATION - NODECO***

LOCATION: ***ST. JOHN'S, NEWFOUNDLAND***

TOPIC : ***HIBERNIA GRAVITY BASE STRUCTURE UPDATE***

BIOGRAPHY: *Fraser Edison was born in Botwood where he received his education graduating from Botwood Regional High School in 1968. Mr. Edison has an extensive background in business, especially in the areas of transportation, finance, and the offshore. From 1975 to 1983, he was employed in the transportation business in St. John's, Grand Falls and Montreal holding key managerial positions in sales and marketing. He also worked on the Churchill Falls Hydro Project in Churchill Falls. In 1982, Mr. Edison and his partners formed Brookfield Investments Limited which owns various companies in Newfoundland. As well in 1982, Mr. Edison and his partners bought Concrete Products of which he is the President. Concrete Products and Doris Engineering from France formed a company called Newfoundland Offshore Development Corporation or Nodeco, of which Mr. Edison is the President. Nodeco submitted a bid to Mobil Oil in 1984 to do the preliminary design of a GBS for the Hibernia Field and were successful in securing this contract. In 1987, Nodeco formed a joint venture with Mcnamara Construction of St. John's, Newfoundland; Atlas Construction of Montreal; Janin Construction of Montreal - calling it Nodeco Joint Venture. The purpose of the joint venture was to bid for the design and construction of the GBS to develop the Hibernia field, and Nodeco was successful in winning this contract in September of 1990. Mr. Edison has been very much involved in the community life. For the past seven years, he has played an active role in the society for the physically disabled and is the Past President of that organization. In January of 1988, Fraser Edison was elected President of the St. John's Board of Trade on which he served two terms.*

SPEAKING NOTES

FRASER H. EDISON

NOIA CONFERENCE

ST. JOHN'S, NEWFOUNDLAND

June 17, 1991

Mr. Chairman, ladies and gentlemen, I am particularly pleased to be invited to address your conference today. I would also like to thank NOIA, our conference hosts, for doing such a splendid job in organizing this event.

Well this is month nine of the Hibernia Development Project and from my perspective, I have a lot of progress to report and projections to make.

As you know, the $1.2 billion dollar contract awarded by the Hibernia Management and Development Company to NODECO back in September was for the design and construction of the GBS, the mating, and tow out.

NODECO is a Joint Venture of engineering and construction firms formed to design and construct the central platform for development of the Hibernia oilfield. NODECO member firms are:

- **Atlas Construction Inc.;**
- **Concrete Products (1982) Limited;**
- **Doris Engineering;**
- **Janin General Contractors Ltd.; and**
- **McNamara Construction Company.**

The scope of the GBS contract is both extensive and varied. It includes:

- **site development;**
- **engineering of the concrete structure and its mechanical outfitting;**
- **construction of the concrete structure;**
- **prefabrication and installation of the mechanical outfitting;**
- **execution of marine operations; and**
- **offshore installation of the completed platform.**

NODECO's building of the gravity base structure will combine state-of-the-art engineering with cost effective design and modern construction methods.

It will also fully support the goal of ensuring that Canadians obtain maximum benefit from the project through employment, training, technology transfer and purchasing policies. I will expand on these benefits and commitments a little later.

The development of the Bull Arm Construction Site in Trinity Bay, Newfoundland will cost approximately $200 million dollars. It is a major undertaking in its own right.

It is constrained by a very rigid time schedule since construction of the concrete structure in the dry dock must commence early in 1992 -- less than a year from now.

The site will cover an area of 1,600 hectares, and will include the following main features:

- a 7.5 km main access road from the Trans Canada Highway:

- a GBS construction area including dry dock, quays, offices, workshops, laydown and storage areas;

- a GBS deep water site connected to land by a 350 meter long pontoon bridge with associated onshore facilities which include concrete batch plants, and materials storage;

- a topsides assembly area which includes a 150 meters long finger pier, a quay and 120,000 m2 of prepared area for further development by the topsides contractor; and

- a 3,000 person accommodation camp with associated kitchen, dining, recreation, swimming pool and commissary facilities, as well as a tavern.

So what is the status of site development at this time. The 7.5 kilometres of road to the dry dock is completed; the road to the topsides area and deep water site are completed to the subgrade level; and camp phase 0 for 400 persons became fully operational in May.

General site preparation and layout and design are underway for phases 1 and 2 of the camp. These phases will be able to accommodate 2,200 workers, and the dining facility will be able to feed 1,000 workers at a time. It will include a recreational complex, an indoor swimming pool and gymnasium and even a tavern, which will serve beer and wine.

ADH/ATCO have recently been awarded the subcontract for design, supply, installation and commissioning of permanent camp dormitories, medical facility, fire hall, as well as kitchen/dining and swimming pool/gymnasium facilities for phases 1 and 2. While Major Offshore is looking after our catering requirements.

Activity in the dry dock area for the initial construction of the GBS is progressing well with the berm more than 50% complete. The berm is an engineering marvel itself. It spans the cove to a distance of 500 metres and is 22 metres deep. The water will be pumped from the cove so as to create a dry dock for GBS construction.

In addition, the dry dock area includes quays, offices, workshops and laydown areas -- all of which is under construction and planning. The basic layout of the topsides area has been finalized and construction of the required infrastructure to support this area will soon be mobile.

The labour force on site currently stands at about 550. it will continue to grow and peak at about 800 in September of this year. Virtually all of the construction labour force are Newfoundlanders and it is anticipated that this will continue to be the case throughout the site development phase. NODECO has made a commitment to give first priority for jobs to residents of Newfoundland and Labrador.

The peak employment period will occur in 1992 and 1993 with 3,000 people employed on construction of the GBS and Topsides.

Some tradespeople and technical staff will be employed by NODECO at the site; others will be hired by companies who secure subcontracts for specific components of the work. Other people will be employed throughout Canada in fabrication yards.

The concrete caissons required for the Topsides Assembly Pier will be constructed in Great Mosquito Cove at the Harbour Works Quay.

The caissons will be constructed by a slip forming method.

In the first stage of construction the walls will be placed about four meters high on the deck of a sinking scow.

When the first stage concrete is completed, the barge will be ballasted with water to permit the partially constructed caisson to float out.

The caisson will then be tied up to the Harbour Works Quay where the second stage slip form operation will complete the concrete to the design height.

The quays will be constructed from precast concrete blocks. The work will be performed at a construction dock and laydown area in the cove, where a concrete batch plant is set up.

There isn't too much to be said about construction of the concrete GBS at this point in time however, in that construction will commence in early 1992.

The GBS is a multi-compartment storage reservoir and support for the production facilities. It consists of a base slab and a caisson that reaches from the seabed to about five metres above the water, with four shafts extending above the caisson to support the topsides.

The Gravity Base Structure will be constructed from about 450 thousand tonnes of high strength, reinforced and post-tensioned concrete.

The base slab and the first 20 meters of the GBS exterior wall will be constructed in a dry dock. A considerable amount of mechanical equipment and pipe work will also be installed at this stage.

The base will then be towed from the dry dock to an inshore deepwater site and moored. At the inshore site, the interior partition walls and the exterior wall will be built to their full height (85 meters).

The top closure slab will be poured, the four shafts extended up to a height of approximately 26 meters above the top closure, and the mechanical outfitting installed in the shafts.

When completed, the GBS will be ballasted down with only a few meters of the shafts exposed above water. The topsides will be positioned on barges and floated over the shafts in the mating operation. The GBS will then be deballasted to lift the topsides off the barges. After mating, the completed platform will be towed to the Hibernia Oilfield and sunk into the prepared seabed where it will become an operating unit.

The GBS and topsides, when installed and ballasted will weigh about 1.2 million tonnes and have storage capacity for about 1.3 million barrels of oil. The enormous mass of the structure is specially designed to withstand the environmental conditions at the Hibernia site, including wave and iceberg loads.

Now let me talk about the engineering. The engineering of the concrete structure and the mechanical outfitting started in Paris, France in October. The NODECO partner with the GBS engineering expertise is DORIS Engineering.

However, the work isn't all being performed by French engineers. NODECO has made a firm commitment to ensure that an effective technology transfer occurs during the project. Therefore, NODECO has retained the services of engineers from Shawmont Newfoundland Ltd. to perform detailed design of site facilities. Shawmont is backed by its parent company MONENCO Consultants Ltd. of Canada.

At this moment there are eleven Shawmont engineers in NODECO's Paris office, and this number will increase to 25 in the near future.

Within a year, the engineering activity will transfer from Paris to St. John's. The Newfoundland engineers in Paris and a number of key French engineers will then form the nucleus of the St. John's Engineering office. It will be necessary to take on an additional 80 or more engineering staff to man this office. This may present some difficulties depending on the engineering work load in the region at that time.

It would of course be easier to complete the engineering in Paris, however, another of NODECO's commitments includes the execution of at least 50% of the design engineering related to GBS in Newfoundland.

With regard to the mechanical outfitting, the installation work will be carried out in Bull Arm. There is approximately 9,000 tonnes of pipe and structural steel required for the mechanical outfitting of the GBS. The prefabrication of this material, however, is another matter.

NODECO and HMDC recently identified ways in which we can break this work down into manageable packages that is consistent with the GBS schedule and thus ensuring that all of the prefabrication work is bid exclusively in Canada. The first of such packages will be issued for tender in the fall of this year. Prequalification activities just concluded with some 75 companies screened.

The list is now reduced to 41 companies. Shop visits to these companies across Canada have just begun. 26 of the 41 companies are located in Atlantic Canada, and 8 here in Newfoundland.

To date, NODECO has awarded some 35 major and minor subcontracts and almost 1,500 purchase orders with a value in excess of $184 million. However, there is much activity remaining in that we anticipate awarding in the range of 250 to 400 major subcontracts.

We have approximately 1,500 companies registered with NODECO's vendor data base, of which almost 1,300 are of Canadian origin.

NODECO has also made a significant commitment to the communities in the construction site impact area. Our expenditure to date within the communities of the Bull Arm area is approximately $370 thousand dollars.

And of course, we are encouraging all of our subcontractors on site to adopt an aggressive local buy policy. We want the communities to benefit from the ongoing activity in Bull Arm. For example, the expenditure in the impact area for just five NODECO subcontractors on site is in excess of $2 million dollars (Green's Service Station, Pitts, Kent Homes, Atlas and McNamara).

The overall objectives of the procurement policy shall be the contracting of goods and services and/or the purchase and delivery of materials and equipment that are:

- **at a minimum cost;**

- consistent with project technical and safety requirements;

- within a time frame which satisfies the master plan; and

- shall optimize Canadian and more particularly Newfoundland content.

Subcontracts to be awarded in the next couple of weeks include:

  - security services;
  - structural foundation monitoring; and
  - quality assurance inspection and laboratory services on concrete.

Amongst the subcontracts which will be called in the next number of months are:

- **onshore communication system;**
- **mobile crane procurement;**
- **submersible pumps;**
- **detailed design of mechanical outfitting;**
- **cement for the GBS;**
- **quality control inspection laboratory services; and**
- **buoyage for marine control.**

One of my duties with NODECO is the responsibility for Canada/Newfoundland Benefits. NODECO is committed to giving a full, fair and timely opportunity in the provision of goods and services to the Newfoundland and Canadian industry on a competitive basis in terms of price, quality and delivery; and employment opportunities to Canadians, with our first consideration to Newfoundland companies and residents, as per the terms of the agreement.

However, there is more to the GBS project than engineering and construction. There are many other components to the project which requires more than the usual amount of attention.

Such things as:

- **Environmental Protection and**
- **Occupational Health and Safety.**

I would now like to provide you with a brief insight into the significance of these two components in the process.

Implicit in all development activities is the need to consider the environment. NODECO is proceeding with the construction project under our commitment to implement a Site Specific Environmental Protection Plan or EPP.

Our EPP specifically addresses the physical disturbances to the environment, socio-economic issues and the specific concerns associated with the commercial fishery. NODECO is not only committed to integrating EPP practices into our project design, but also monitoring project related effects throughout the life of the project.

Since day one we have had an environmental monitor on the site, assisting in the coordination of construction activities and addressing environmental concerns. Several months ago, a community liaison officer and a fisheries liaison officer received appointment. Their role is to ensure that the concerns and queries of residents and industry in the impact area are readily addressed.

The aforementioned, plus an environmental specialist in St. John's all report to our environment manager who reports directly to the project manager. We are not taking our commitments to the environment lightly.

With regards to occupational health and safety, NODECO complies with the guidelines set out by the Newfoundland Department of Labour in conjunction with the Canada Newfoundland Offshore Petroleum Board. In addition, NODECO has prepared policies and procedures detailing how we will comply.

The site safety procedures allow for a thorough site orientation, safety measures and techniques, and accident reporting requirements. Our safety and medical personnel on site are accessible 24 hours a day. The subcontract for medical services for the Bull Arm Construction Site was awarded to Atlantic Offshore Medical Services.

Our safety record is to be envied by the construction industry. The Canadian national average for the construction industry is 12 accidents for every 200,000 person hours of work. The international average for the industry is 11 accidents for every 200,000 hours worked. NODECO's average at the Bull Arm Construction Site is only 8.26 accidents by the same person hour standard.

This, ladies and gentlemen, is a record we at NODECO and the workers on the site are very proud of.

We are not assuming any of our commitments lightly. NODECO has made a commitment to HMDC to supply the Hibernia Production Platform within time, and within budget. We have made commitments to the people of Newfoundland and Canada to maximize desired benefits of this multi billion dollar project. We have made commitments to the generation of people who will be living and working offshore on the platform well into the next century to supply them with a safe, reliable and effective structure.

We intend to realize all of our commitments because of our own personal obligations to do a job and do it right, and thus realizing the creation of a new industry for Newfoundland and Canada.

I would now like to show a brief video formally introducing NODECO, the project and progress at the construction site. Thank you.

SPEAKER : **L.F. ROLSTAD**

COMPANY : **NEWFOUNDLAND OFFSHORE CONTRACTORS - NOC**

LOCATION: **MONTREAL, QUEBEC**

TOPIC : **HIBERNIA TOPSIDES UPDATE**

BIOGRAPHY: Dick Rolstad graduated from the University of St. Andrews, UK with a Bachelor of Science Degree in Applied Science (mechanical engineering) in 1965. He has been involved in the engineering side of 3 major projects in the North Sea. Mr. Rolstad has been in various management positions with such companies as Aker, Statoil, and Saga Petroleum. He is presently Managing Director with Aker Offshore Enterprises in Oslo, Norway.

Presentation to the NOIA Conference
Hibernia Topsides Update
Description of Facilities

By: L.F. Rolstad
Project Manager
Newfoundland Offshore Contractors

June 17, 1991

Authors: L.F. Rolstad
V. Punj

Hibernia Topsides Update - Description of Facilities

SLIDE #

1.0 Introduction 1

Mr. Chairman; Ladies and Gentlemen. Good morning. I will not spend much time beating around the bush as I have a lot of gound to cover.

The subject of my presentation is the Topsides concept selected for the Hibernia Project. This concept has been refined through preliminary engineering, and is now in the early phases of detailed engineering by Newfoundland Offshore Contractors (NOC) in both Montreal and St. John's. 2

The Topsides concept selected for the Hibernia production
facility is an integraged deck structure which utilizes five
large modules - commonly called Super modules - and
seven Topside - mounted structures. This, as well as
several other unique and innovative features, has helped
to make the overall project viable. Before going into 3
detail, let me say a few words about the companies behind
NOC - Newfoundland Offshore Contractors.

Thereafter I will go into some more detail of the Topside facilities themselves and will, through this and the slides, give an impression of our progress to date.

NOC is a joint venture of five companies (Aker Engineering, BFL Consultants, Brown & Root Marine, Monenco and SNC), three Canadian and two North Sea companies under contract to the Hibernia Management and Development Company (HMDC) to perform the Engineering 4 and Procurement work for the Hibernia Topsides facilities. As such, we are responsible for preliminary engineering, detailed engineering and procurement. In addition, we provide project management and support services (project services) to HMDC for the complete project.

Our contract was awarded in September of last year and since then we have established a complete project organization located in two office facilities - one in St. John's and one in Montreal. We now have some 470 people working on the Engineering and Procurement portion of the project, as well as 53 on Project Support Services.

In the period since the contract award we have focused our efforts in two areas, namely:

1. developing the Topsides concept further through pre-engineering;
2. Building an effective project team to manage and perform the work. Team building has been undertaken in concert with our client, HMDC, who are themselves devoting considerable effort to this subject.

5

Establishing two effectively interfacing teams has in itself been a challenge when you realize that the players who make up the Topsides organization come from a total of nine companies - four in the owners' consortium and five in the NOC consortium.

The size of the challenge ahead is considerable. The introduction of major technical innovations such as the super module concept; the desire to use and transfer North Sea technology to our Canadian colleagues; the massive use of CAD (Computer Assisted Design); and the special environmental conditions which prevail both at the Hibernia site, and during fabrication, transport, assembly and hook-up; all add to the complexity of the project.

SLIDE #

To accomplish this task, we have assigned ourselves a mission. Quite simply, our mission is to engineer and procure materials and equipment for the Hibernia Topsides production facility - Canada's largest such facility and the first ever to use the SuperModule approach - meeting the requirements specified, and ensuring that our client achieves first oil on schedule in 1996. 6

To carry out the detailed engineering, we at NOC have structured our organization around the five major Topsides modules (or Super modules), setting up Senior Project Engineers as mini project managers for the detailed design of each module. This approach is intended to break the design down into manageable packages, and ensures focus and a dedicated effort towards each module. It also ensures that the complex problems of space and weight restriction are fully addressed and coordinated. 7

On the engineering side, one of the tools that we are using to address the challenge of a congested Topsides production facility and to make the piping "clash free", is a three dimensional computer model of the Topside facilities. This is one of the most extensive uses of 3D CAD ever employed in North America and represents a 8 significant challenge and investment. Although the use of the 3D model will have little effect on the engineering manhours, it will provide substantial benefits down the road in the form of major savings in the cost of construction. This topic will, however, be addressed tomorrow in detail by Derek Langford, the NOC Engineering Manager.

2.0 Background to the Current Concept 9

To move on to the Topsides design itself, I will begin by 10
reviewing a little history. The Mobil Beryl A, contracted in 1973 and installed in 1975 for Mobil North Sea Ltd., U.K., was the first major structure to combine an integrated deck with a giant concrete gravity base. An integrated deck was not, however, the concept originally considered for Hibernia. The initial Hibernia topsides concept was based on the configuration of the Norwegian Statfjord platforms designed in the late 1970's.

As applied to Hibernia, the Statfjord concept consisted of 16 small modules (1000 - 2000 tonnes each) on top of a Module Support Frame (or MSF), giving an overall dry Topside weight of 44,000 tonnes. In this design, the modules were to be installed on the MSF inshore, using heavy lift crane vessels after the mating of the Topsides with the GBS. Even as larger heavy lift crane barges have become available - which in turn has allowed fewer but larger modules to be placed on top of the MSF - it was clear that the MSF approach would not fully achieve the weight and commissioning benefits, for Hibernia, of the earlier Mobil Beryl A type integrated deck, completed onshore.

Recent developments in integrated deck design, however, suggested that it would be possible to divide the fully integrated deck into a limited number of super sized modules. These modules would be fabricated and commissioned at different sites and transported individually to a common assembly site. There these modules would be joined together to make one major integrated deck structure, thereby eliminating the need for an MSF. By using skidding or trailer technology instead of heavy lift vessels to bring the modules together, considerable savings in weight, cost and time would be achieved, along with reduced fabrication congestion at the main assembly site. Thus the benefits of an integrated deck structure, with full onshore completion, could be retained. 11

After studying the feasibility of applying this concept to
the project, the Hibernia consortium accepted the new
integrated deck design. It allows a 20 to 25 per cent
weight reduction, mostly in structural steel, while
retaining all of the design, production and safety criteria.
The new design has eliminated the MSF and accommodated 12
the topsides in five large modules and seven smaller
topside mounted structures, for a total weight of 35,000
tonnes at tow-out.

Furthermore, the new concept not only results in significant cost savings, but also enhances the operational safety of the platform, ensuring that the Process Module M10 and the Living Quarters are located at each end of the platform.

In addition to the cost savings which naturally flow from a significant reduction in the Topsides weight, the super module concept also reduces assembly and hook-up costs. Because the super-modules are designed to be self contained units, completion and commissioning can be carried out, for the most part, at the various module fabrication sites.

This spreads the work around, prevents major bottlenecks at the assembly site and dramatically reduces inshore and offshore hook-up work, and thus cost.

Current plans call for the modules and Topside-mounted structures for the new design to be fabricated at various locations, loaded onto large transportation barges by means of skidding or multi-wheeled trailers, and then transported here to Newfoundland to the Great Mosquito Cove assembly pier in Bull Arm, adjacent to the GBS construction dry dock.

SLIDE #

3.0 Overall Functional Requirements

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The selected Topsides approach is well-suited to the operational requirements of the platform. Before going on and discussing the individual modules, I will begin by briefly reviewing the overall functional requirements as they are defined by the pre-engineering.

The oil production will be from two principal reservoirs, the Hibernia Sandstones and the Avalon Sandstones. The estimated production life of the field is 21 years. The production strategy concentrates on development of the Hibernia Reservoir, and provides for stepped development of the Avalon depending on well performance. Well pressure will be maintained with the use of water injection - 220,000 barrels per day at peak - as well as gas injection. The principal production scheme is a 3 stage separation process with 5 stages of gas compression. 14

To meet operational requirements, the platform will have a peak production of 150,000 barrels of oil per day and it will be able to store and deliver this product via a tanker loading system to shuttle tankers for delivery to shore. 15

Current plans allow for a total of 83 wells, with 64 wellslots being provided on the platform. Of these 83 wells it is envisaged that a total of 49 wells will be used for production, 6 wells will be used for gas injection and 28 wells will be used for water injection.

4.0 Major Topside Components

I will now go into a little more detail on the technical aspects of the revised design. Most of you will be aware that the Topsides, as a unit, is nearly the size of two soccer fields. In overall dimensions, it is approximately 156m long (32.5 + 94.2 + 30) including the boatstations; 84 m wide (60 +12 +12) including the canitlevered sections; and 103.5 m to the top of the drilling derrick. The actual deck structure is 31.5 m high.

Each supermodule is in the range of 18 to 19.7 m wide (19.7 + 18 + 19 + 18 + 19), 84 m long and 31.5 m high, and weigh between 4,500 and 8,000 tonnes. The individual modules of the Hibernia topsides facilities are described in the following:

4.1 M10 Process Module

SLIDE #
16

The Process Module M10 is the process area for the platform. All directly- related process equipment downstream of the wellhead choke valves and up to the crude line to storage, is accomodated within this module. 17

The principal items of equipment in the module are the various platform manifolds, the high pressure, the medium pressure, and low pressure separators, two gas compression trains and the produced water treatment system. The piping layout for the well connections and manifold areas located in both the M10 and M20 modules is critical as this represents the heart of the platform layout. 18

Detailed studies have been performed to accomodate the densely-packed equipment and piping within the volumetric envelope of these modules, and the picture shows the final layouts which are based on the principal of full inter-changeability for all wells. That is, every christmas tree (production valve assembly) can be connected to the production, test, water injection or gas injection manifolds as required by the drilling program, resulting in a very large manifold arrangement.

SLIDE #

4.2 M20 Wellhead & Drilling Module 19

Much consideration has also been given to the hazard and explosion criteria for the M20 module so as to provide the highest level of safety for personnel and the platform.

The wellhead and christmas trees have been located in Module M20 with 32 wells in each drill shaft. The drilling related equipment, e.g., cuttings cleaning, blow-out preventer (BOP) and wireline units - are also contained within this module. 20

4.3 Module M20 Drilling Facilities

The topside drilling facilities themsleves, located over the M20 weather deck, consist of two drilling derricks and related equipment. These will be capable of drilling wells to a total depth of 7900 metres (26,000 ft) through conductors located in the two drilling shafts of the gravity base structure. 21

The two drilling rig facilities will be used to drill and complete up to 64 platform wells, with each shaft being served by an independent drilling unit. The only shared facilities between the two drilling rigs will be the well test and drainage clean-up units, cuttings cleaning equipment, the pipe rack and the cementing unit.

The two drilling sub-structures and drilling derricks are identical. The drilling sub-structures on the top of M20 are elevated to ensure that there is adequate clearance above the module. This allows the use of the entire surface of the module for production-related operations.

Drilling and production will take place simultaneously. The production valve assemblies will be located on the 125 m elevation deck, while the BOP will be located on the 129 m elevation deck.

4.4 M30 Mud Module 22

The Mud module, M30, contains equipment to provide the complete mud and cementing process, as well as storage and High Pressure pumping services for two drilling units. The two lower decks of M30 accommodate sea water 23

SLIDE #

injection and future produced water injection systems. The platform cranes are also located on this module. The roof of the module will support the pipe rack, complete with a gantry crane, pipe transporter and catwalk pipe handling system for each of the two rigs. 24

4.5 M40 Utility Module 25

The utility module, M40, contains all the utility service facilities for the platform. The main power generation equipment is contained within this module. Footprint sizes for the main generators have been developed based on two major gas turbine power units which fit well within the established module size. In addition to the main power generators, the module also contains high and low voltage switchgear, platform stores and workshops, heating medium systems for the LP/test separator heaters and HVAC and various utility services. 26

SLIDE #

4.6 M50 - Living Quarters Module 27

As I already mentioned, the living quarters has been located at the south end of the platform in order to afford 28 maximum protection to the personnel by separating them from the wellbay and process areas, which are located to the north.

The living quarters module, M50, is designed to accommodate 280 people in double cabins, with 50 per cent of the cabins having windows. The sleeping areas have been separated from the utility areas to minimize noise problems. The two lower decks in M50 are dedicated to essential and emergency services for the platform as well as the main control centre and offices. There are three diesel powered essential/emergency service generators rated at approximately 1.5 MW each, and five dedicated diesel electrical generators for the five fire pumps located in the GBS.

The living quarters level 3 accomodates the dining area, kitchen, main washroom, changing room and laundry facilities.

SLIDE #

Level 4 contains game and exercise rooms together with 26 two-man cabins.

Levels 5 and 6 contains mainly cabins (96 two-person cabins) in addition to a lounge and a library.

Level 7 has 18 two-person cabins, a driller's washroom, skylobby and a radio room. Also located at this top level of the LQ is the hospital facilities, which has easy access to the helideck above for the evacuation of injured personnel should this occur.

4.7 Major Equipment 29

In addition to the modules themselves, there are a number of items of major equipment. Each item has been laid out to maximize operational and maintenance access to it. This means that any piece of equipment can be removed from its location to a laydown area served by the two cranes.

I have already mentioned that the power will be supplied by two major gas turbine powered generators. Incidentally, this generating capacity equals that supplied for a town with a population of 40,000.

In this context it should be noted that the power requirements for this platform are greater than usual because:

- two (2) drilling rigs will be operating simultaneously with the drilling program taking some 7 years.
- of a water injection system with a maximum capacity of 220,000 bpd.
- when in use, the crude oil offshore loading system should operate simultaneously with drilling and water injection;
- 280 persons will be accomodated in the living quarters.

Other major equipment worth noting includes:

- two large heating medium fired heaters located in M40 for:
  - crude oil heating
  - platform HVAC

Various process equipment comprising:

- platform manifolds (production, test, water injection and gas injection)
- separators (HP, MP & LP & Test separators)

- two gas compression trains with 2 turbine and 1 motor driven compressor providing 5 stages of compression.
- three water injection pump skids, which together with filterer packages, dearator, etc. will provide the necessary water injection capacity.
- two cranes with a boom length allowing 15 tonnes lift at a reach of 57m from supply vessels located 45m outside of the GBS boundary.

5.0 Special Features of the Design

Having acquainted you with the Topsides design, I would now like to highlight some of the special features.
I will start with safety.

5.1 Safety 30

The one single principle governing safety in layout design 31
has been to restrict hazardous equipment and classified areas to the north of the M20/M30 bulkheads, as far away as possible from the living quarters. This objective has been achieved. For escape routes, straight access ways outside the modules on main deck level and main mezanine

level lead to the quarters and main lifeboat area or alternatively run to the north lifeboat and muster area. At weather deck level, the area south of the wellhead module is served by access ways to the quarters area.

As well, personnel escape routes have been established from the various levels of the wellhead module into the mud module, which in turn has centrally located escape routes into the M40 utility module and from there into the Living Quarters.

Lifeboats or other evacuation means are provided at the North and South ends of the platform, with muster stations as appropriate for the evacuation method used. If lifeboats are used, they will be oriented away from the platform and cantilevered out a minimum of 15 metres outside the GBS boundary to ensure that the lifeboat, when lowered, is not carried by waves back into the GBS caisson. However, alternative dry evacuation methods are now also being investigated.

SLIDE #

5.2 Structural and Layout Features

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There are also a number of structural and layout features that are worth noting. Because the Topsides concept is designed as a modularized integrated deck structure, the 33 five main modules welded together provide the global strength of the integrated deck.

The main structural load-carrying system consists of transverse plate girder bulkheads and longitudinal trusses. The four main transverse bulkheads are of double plate construction, 1500 mm wide. They span the full height and width of the modules. Their main purpose is to provide platform transverse rigidity and to transfer topside loads to the GBS shafts.

The east and west cantilevered parts of the modules serve primarily as supports for the deck during the deck transport operation, and provide deck area for equipment laydown, etc., during operations.

With the exception of the north face of the process module which is of open truss construction, all other transverse bulkheads are of stiffened plate construction.

The longitudinal trusses are open truss systems, with the trusses supporting the cantilevered Process and Living Quarters modules, and also providing longitudinal rigidity for the platform.

The connection between the Topsides and the GBS is achieved by eight cast steel transition pieces, two per shaft located underneath the bulkheads of modules M20 and M40. 34

The size of the modules, together with the location of the transition pieces, gives the Topsides a very direct load path through the structure, with a resulting low weight.

The structural integrity during fabrication and transport of each module will be made up of one half of the transverse plate girder bulkhead on each side of the module and the appropiate part of the longitudinal truss section across the module. 35

A unique feature of the structural analysis is that the modules are designed both to maintain the structural integrity of separate modules during the temporary phase and as a component of the integrated deck once modules are welded together. The latter is a consequence of eliminating the MSF. 36

For the temporary phase, separate structural analysis is carried out for each module and topside mounted structure using super elements. The structural analysis is carried out using the FASTRUDL finite element package. The main loading conditions for the individual super element for the temporary phase are load-out, transportation, and load-on to the assembly pier.

The global analysis of the super elements is carried out by connecting the boundary nodes of each super element to form the complete integrated deck structure. The main loading conditions for the global analysis are tow-out of deck for mating with the GBS and various operational conditions. 37

The key data for the structural analysis model is listed below:

Number of Super Elements	8
Approximate number of Finite Elements	9300
Approximate number of Joints	6300
(Number of) Degrees of Freedom	30,000

SLIDE #

5.3 Bulkhead Tanks and Central Piperack 38

The 1.5 metre void between the super-modules is well 39 utilized in the new design, as it now accomodates bulkhead tankage for drill water, fresh water and mineral oil. This arrangement provides a very efficient use of the space available and is also weight-efficient since the tankage is contained within the existing structurally-stiffened bulkheads.

The establishment of a central piperack and services routing centrally on the lower main deck level has concentrated the bulk of piping and cabling in one area, thereby simplifying the layout and hook-up of piping and other services.

To alleviate congestion on the central piperack however, external piperacks are used for emergency and essential services. This provides an alternate safe routing for such services.

All modules have vertical pipe, cable trays and HVAC ducts which lead off the central piperack and extend the full module height thereby connecting the various levels of each module.

5.4 Weight 40

The topsides load-out weight and vertical centre of gravity is critical during the Topsides and GBS mating and platform tow to the field. A Topsides load-out weight of 35,000 tonnes has been specified for the GBS design. 41

Weight control and monitoring has a high priority in order to ensure that the weight limitations are achieved. The vertical centre of gravity must also stay within the specified limits.

To reduce the Topsides weight, use of high strength steel and aluminum is being considered. Weight will also be one of the governing factors when selecting equipment.

5.5 Environmental Loads (Ice on Structure) 42

Any snow and ice loads anticipated are to be included as live loads. Atmospheric icing will be especially critical on wind sensitive topsides mounted structures (such as the flare boom, life boat platforms, helideck, and the derrick), which are comprised of many small members on which significant amounts of ice can accumulate and where the wind loads will be significantly increased by the ice accumulation.

6.0 Transportation 43

I now want to look at the transportation of completed modules, as this will be a major challenge. Four of the five supermodules could be fabricated in existing facilities outside Canada. Some of these facilities are located in northern and southern Europe and in the Gulf of Mexico. 44

Either location would involve a voyage of approximately 3000 nautical miles to Newfoundland. Others are located in Japan and Korea, a voyage of about 12,000 nautical miles - about half way round the globe. These voyages, at say 10 knots, take around 15 days from Europe and 50 days from the Far East - mostly across open ocean.

In addition to transporting these very large modules long distances across the open seas, another challenge is to design the modules and their sea-fastenings to survive winds and waves which they may encounter en route. In this case, all the routes end with a crossing of the northern North Atlantic in the winter or early spring of 1994.

Elsewhere on some of the other routes, there may also be typhoons and hurricanes to avoid. The master of the voyages will of course always try to choose routes which avoid such conditions.

Coming into Newfoundland in the late winter of 1994, there is also a need to consider floating ice and ice build-up on the module and its transport vessel. 45

Thorough analyses of the loaded transport vessel's stability, motions, accelerations and the resulting forces and stresses in the vessel is required to ensure that the module and the sea-fastenings provide for a safe journey. As a point of reference, accelerations in the order of 1g, and extreme roll angles of 20-25 degrees, could be experienced, depending on the module/barge or vessel configuration.

To accommodate potentially harsh environment conditions during a tow, the design sea state for modules under tow is a maximum wave height in the order of 28 metres (95 feet) and wind velocities of approximately 40 m/sec.

There is a limited fleet of the largest self-propelled vessels or towed barges capable of carrying this type of on-deck cargo under such conditions. The challenge of the engineering is therefore to design the module and the sea fastenings so that these voyages are both safe and economical, yet require a minimum of extra strengthening of the supermodule structure itself, which would add weight to the permanent Topsides main steel structure.

SLIDE #

7.0 Module Load On/Off 47

The loading of modules on and off the transport vessels will be yet another challenge that has to be taken into account when designing the modules. Large capacity pneumatic-tired trailers are now available to do the job. These can make the job both easier and quicker. 48

On the other hand, conventional skidding techniques are still available. Regardless of the motive technique used, it will be necessary to plan for counter shifts of load and tides. This however is normal, and proven technology is available.

The module load on/load off will require mobilization of some of the world's major transport trailers or skidding equipment. One problem will be to have sufficient capacity both at the assembly site in Bull Arm and at other fabrication yards at the same time. Due to the number of modules, the heavy weights and the restricted time in which the operations are to take place, careful scheduling of the load on/off and the sea transportation is of vital importance.

8.0 Assembly Site

At the assembly site the modules will be loaded either directly from the fabrication site, or from the transportation vessels (again by skidding or trailers) onto the purpose-built assembly pier. Then they will be joined together into a single unit, thereby avoiding the need for a heavy lift crane and saving costs.

The modules are joined by welding infill beam sections to the truss chords at the main, central and weather deck elevations of the longitudinal trusses, hence forming a complete deck truss system. 49 In addition, pairs of modules are connected through their common cast transition pieces. 50 Deck plating of the weather deck is continous. Other connectors are classified as not contibuting to the global strength of the deck. (For an impression of the size it can be noted that the height of the Bottom Beam (Elev. = 114) equals 1.5 meters).

The lifting of the flare, drilling sub-structure, helicopter deck and lifeboat platforms require the use of a medium-sized barge-mounted shear leg crane or revolving crane. Approximate required lifting capacity is in the range of 500 - 600 tonnes. 51

9.0 Mechanical Hook-up 52

The mechanical hook-up between the modules is the next challenge. Each module is designed as a self-contained unit and can be completed as such . A key feature of the fabrication bid evaluation will therefore be the fabricator's ability and track record in delivering modules which are mechanically complete and tested prior to shipment from their fabrication yards.

Hook-up work at the assembly site in Bull Arm will consist of joining the module structures to form one global Topside structure, and completion of platform system connections between modules and topsides mounted equipment. Prior to tow-out of the Topsides to the mating site, systems are to be mechanically completed, tested and partially commissioned (to the extent practical). 53

10.0 GBS Mating/Tow to Field

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After the modules are assembled and the installation of the modules and topside mounted equipment is complete, the Topsides is lifted from its assembly position by two barges (a catamaran tow) and is towed to the deep water site for mating with the GBS and subsequent hook-up. (The platform is then towed to the Hibernia oil field for installation at its pre-designated location).

55

11.0 Conclusion

So that covers the main design features and stages of the Topsides concept. To conclude my presentation, I want to summarize our progress to date in achieving our mission, and to look ahead.

As I said at the beginning, our mission is to design and engineer as well as procure materials and equipment for the Hibernia Topsides production facility, and to ensure that all requirements are met.

This involves a number of challenges, some of which we have met, and others of which we are on the way to meeting. Some of our achievements to date include: 56

- Mustering a team of some 470 highly qualified people ready to embark on the detailed engineering and procurement for one of the largest engineering and procurement efforts to have been undertaken in Canada.

- Within a limited time period, establishing effective office facilities in Montreal and St. John's.

- Establishing one of the largest computer facilities used on an engineering project in Canada.

- Initiating the extensive use of CAD, including an ambitious training scheme.

- Delivering the Bull Arm Topsides Site Devlopment and the M20 module packages on time (at the 1st and 28th of April respectively), to our client's satisfaction.

SLIDE #

- Substantially completing pre-engineering, with a strong focus on agreeing and completing P & IDs, platform layout, and safety aspects.

- Establishing effective working relations - not least due to our client's teambuilding initiative.

Looking ahead we can see a number of major challenges to come:

57

- Ensuring that quality standards are met at a variety of locations.
- Maximizing use of Canadian skills, experience, equipment and materials.
- Ensuring market availability of major equipment and bulks.
- Managing materials logistics.
- Achieving the very tight schedule in engineering and fabrication and completing all modules on time.

SLIDE #

To do this, we will have to concentrate on:

- Getting all P.O.'s out on time.
- Securing vendor information in advance to ensure that sufficient information is available on drawings and documents .
- Issuing requests for fabrication bids and placing contracts on time, and with a sound content.

An additional challenge will be to design what will be the first offshore platform to be built to Canadian/CSA standards. These are standards that have never been fully applied before. 58

Further we need to:

- Ensure technology transfer to Canadians in spite of time limitations;
- Manage the weight through effective design, so that the Topsides weight stays within the stated limits;
- Maximize use of 3D CAD to ensure a "clash free" design.

As well as:

- Support HMDC 's efforts through the Project Services Contract.

SLIDE #

In spite of the number and complexity of these challenges, I am quite sure that with the highly qualified team NOC now has on board, and the good relationship we have established with HMDC and Canadian industry, we will, in four to five years time, be in a position to add all of these to our list of achievements. 59

- End -

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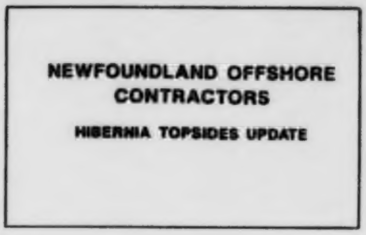

NEWFOUNDLAND OFFSHORE CONTRACTORS

HIBERNIA TOPSIDES UPDATE

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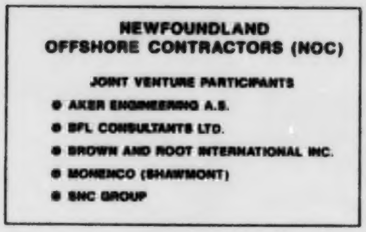

NEWFOUNDLAND OFFSHORE CONTRACTORS (NOC)

JOINT VENTURE PARTICIPANTS

- AKER ENGINEERING A.S.
- SFL CONSULTANTS LTD.
- BROWN AND ROOT INTERNATIONAL INC.
- MONENCO (SHAWMONT)
- SNC GROUP

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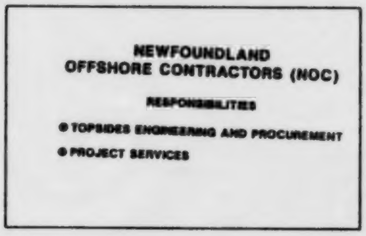


NEWFOUNDLAND OFFSHORE CONTRACTORS (NOC)

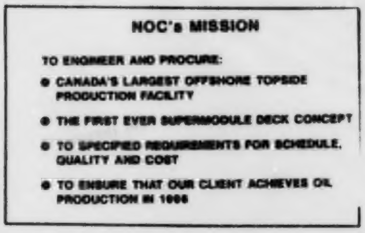
RESPONSIBILITIES

- TOPSIDES ENGINEERING AND PROCUREMENT
- PROJECT SERVICES

5

NOC & HIBERNIA

6

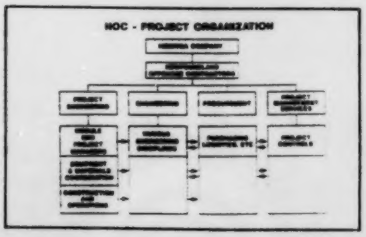


NOC's MISSION

TO ENGINEER AND PROCURE:

- CANADA'S LARGEST OFFSHORE TOPSIDE PRODUCTION FACILITY
- THE FIRST EVER SUPERMODULE DECK CONCEPT
- TO SPECIFIED REQUIREMENTS FOR SCHEDULE, QUALITY AND COST
- TO ENSURE THAT OUR CLIENT ACHIEVES OIL PRODUCTION IN 1996

7



NOC - PROJECT ORGANIZATION

8

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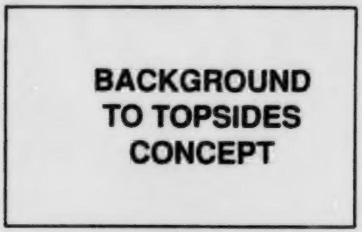

BACKGROUND TO TOPSIDES CONCEPT

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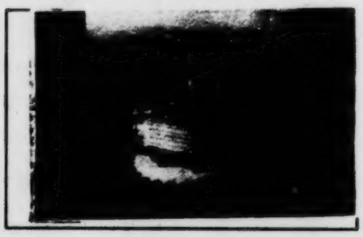

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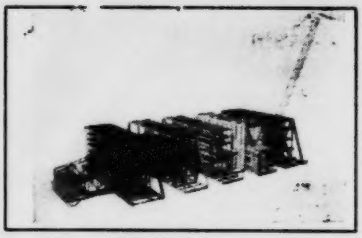

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TOPSIDES CONSTRUCTION AND ASSEMBLY

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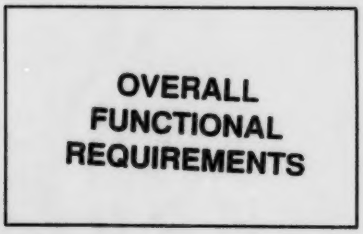
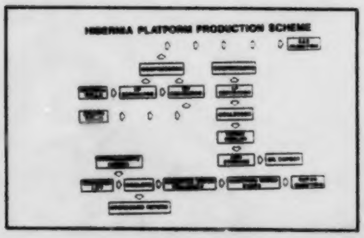


OVERALL FUNCTIONAL REQUIREMENTS

14

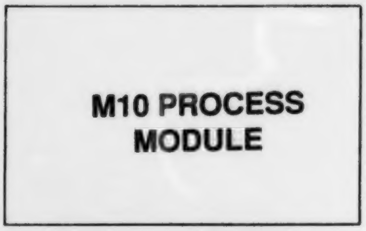


HIBERNIA PLATFORM PRODUCTION SCHEME

15

HIBERNIA PRODUCTION SYSTEM COMPONENTS

16


M10 PROCESS
MODULE

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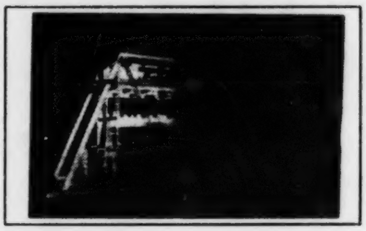

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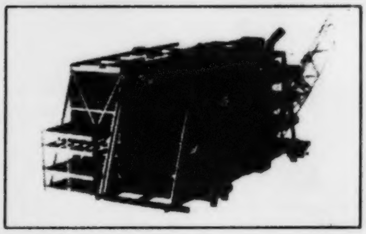

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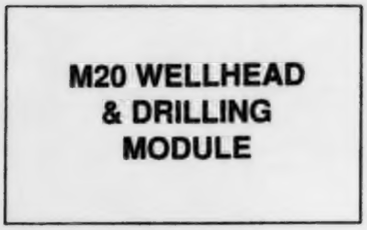
M20 WELLHEAD
& DRILLING
MODULE

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M30 MUD
MODULE

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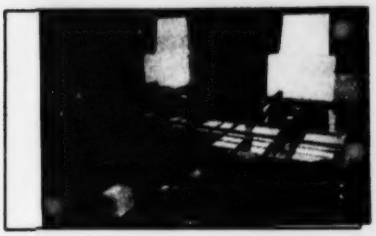

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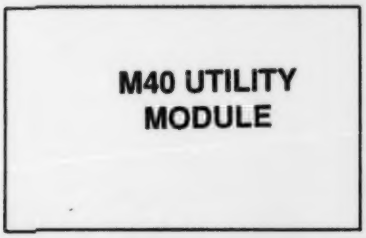
M40 UTILITY
MODULE

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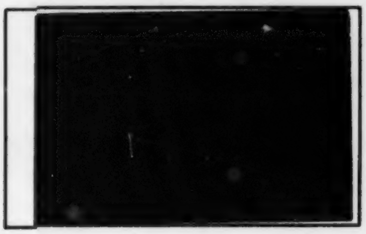

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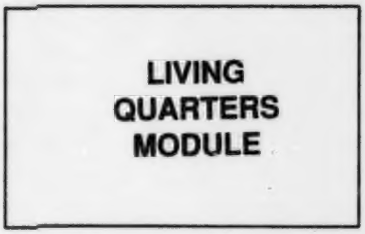
LIVING
QUARTERS
MODULE

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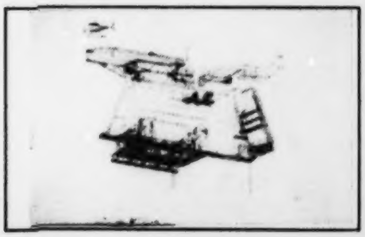

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SAFETY

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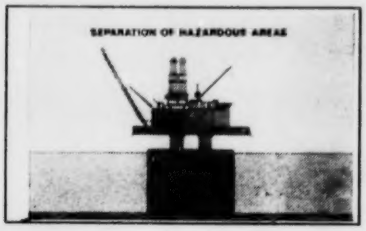
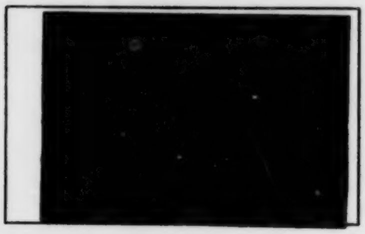


SEPARATION OF HAZARDOUS AREAS

32

STRUCTURAL
& LAYOUT
FEATURES

33



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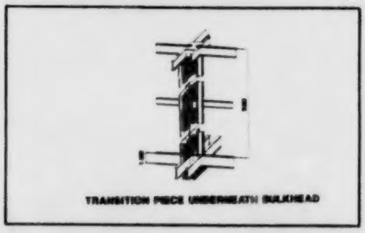

TRANSITION PIECE UNDERNEATH BULKHEAD

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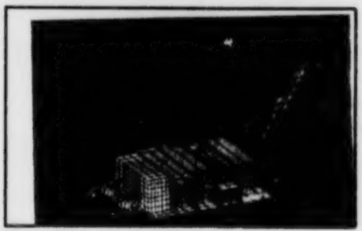

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BULKHEAD TANKS
& CENTRAL
PIPERACK

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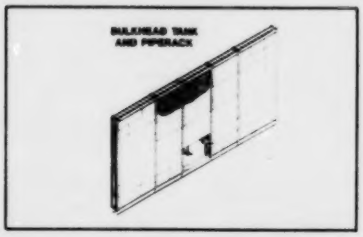

BULKHEAD TANK
AND PIPERACK

40

WEIGHT

41

42

43

TRANSPORTATION

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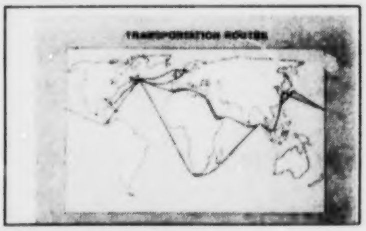
TRANSPORTATION ROUTES

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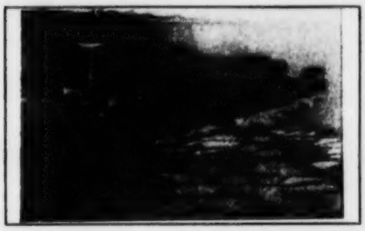

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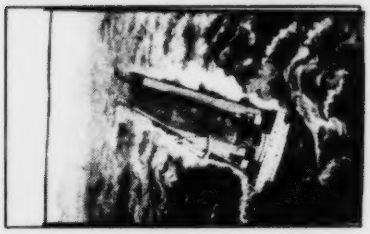

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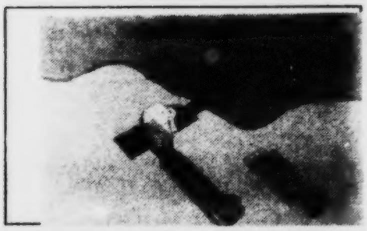

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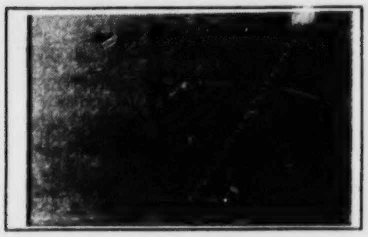

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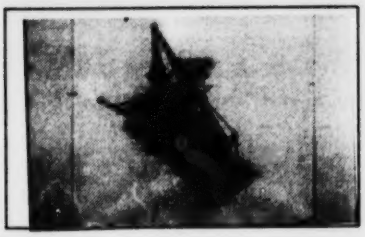

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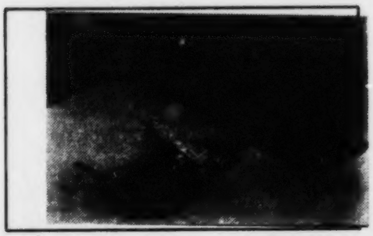
MECHANICAL HOOK-UP

53



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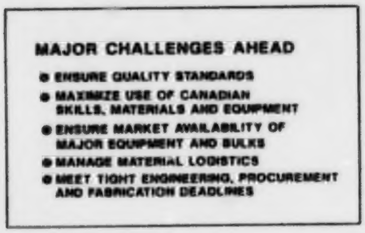
CONCLUSION

56

ACHIEVEMENTS

- TWO NEW OFFICES, MONTREAL AND ST. JOHN'S
- ONE OF THE LARGEST COMPUTER FACILITIES USED IN A CANADIAN ENGINEERING PROJECT
- EXTENSIVE USE OF 3D CAD IN ENGINEERING
- ON TIME DELIVERY OF BULL ARM TOPSIDES CONTRACT PACKAGES
- SUBSTANTIAL COMPLETION OF PRE-ENGINEERING
- EFFECTIVE TEAM BUILDING AND CLIENT RELATIONS

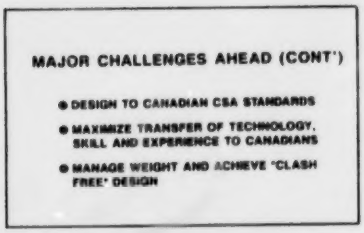
57



MAJOR CHALLENGES AHEAD

- ENSURE QUALITY STANDARDS
- MAXIMIZE USE OF CANADIAN SKILLS, MATERIALS AND EQUIPMENT
- ENSURE MARKET AVAILABILITY OF MAJOR EQUIPMENT AND BULKS
- MANAGE MATERIAL LOGISTICS
- MEET TIGHT ENGINEERING, PROCUREMENT AND FABRICATION DEADLINES

58



MAJOR CHALLENGES AHEAD (CONT')

- DESIGN TO CANADIAN CSA STANDARDS
- MAXIMIZE TRANSFER OF TECHNOLOGY, SKILL AND EXPERIENCE TO CANADIANS
- MANAGE WEIGHT AND ACHIEVE "CLASH FREE" DESIGN

59

SPEAKER : D.J. CROSTON

COMPANY : LLOYD'S REGISTER OF SHIPPING

LOCATION: MONTREAL, QUEBEC

TOPIC : ROLE OF THE CERTIFYING AUTHORITY

BIOGRAPHY: David Croston has worked in the marine and offshore industries for 25 years and is currently the Certifying Authority Project Manager in Canada with responsibility for Lloyd's Register's activities on the Hibernia Project.

After completing a seagoing marine engineering apprenticeship with Alfred Holt and Company of Liverpool, england, he studied at the University of Newcastle upon Tyne graduating in 1972 with a B. Sc. In Naval Architecture. He then spent two years with the U.K. Department of Trade & Industry (marine division) in Newcastle as a Ship Surveyor working primarily on approval of ship stability and then, in 1974 moved to work in the North Sea construction industry on offshore pipelaying and platform installation.

In 1976 he joined Lloyd's Register in their offshore division as a Contract Engineer and has worked on a number of offshore projects in the North Sea, Irish Sea, and Offshore Abu Dhabi. He was the Senior Contract Engineer on Mobil's Beryl "B" and second S.P.M. Projects, and then Britoll's Clyde Project, where he was based in Glasgow. From 1987 to March this year as the Lloyd's Register Certification Project Manager for the Mossel Bay Offshore Gas Development Project he was based in Cape Town, South Africa.

ROLE OF THE CERTIFYING AUTHORITY ON THE HIBERNIA DEVELOPMENT PROJECT

BY

D.J. CROSTON

Presented at Newfoundland Offshore Industries Association Conference, held in St. John's Newfoundland on 17 - 19 June 1991

THE ROLE OF THE CERTIFYING AUTHORITY ON THE HIBERNIA DEVELOPMENT PROJECT

SUMMARY

This paper examines the certification process for the Hibernia Project. It describes the legislative principles to be applied and the activities undertaken by the certifying authority to enable it to issue a certificate of fitness, once satisfied that the installation is:

a) Designed, constructed, transported and installed or established in accordance with Canadian legislative requirements,

b) Fit for its intended purpose and can operate safely with due consideration to the environment

and

c) Able to continue to satisfy the requirements of (a) and (b) if it is maintained in accordance with the inspection, maintenance and weight control programmes approved by the certifying authority.

THE ROLE OF THE CERTIFYING AUTHORITY ON THE HIBERNIA DEVELOPMENT PROJECT

By

D.J. Croston

INTRODUCTION

Thirteen men lost their lives on Monday 27th December 1965 when the self elevating drilling barge, Sea Gem collapsed, capsized and sank in the North Sea. The tribunal enquiry into the loss concluded that the collapse was probably due to the failure of certain parts of the jacking mechanism which had not been designed to operate in the winter conditions of the North Sea. It was also found that certain important requirements of the current code of practice applicable to the working of an offshore drilling vessel and voluntarily in use at the time had not been observed.

The recommendations resulting from this tribunal included a call for statutory regulations to control the safety, health and welfare of offshore installations. The resulting Offshore Installations (Construction & Survey) Regulations issued by the U.K. Government in 1974 required all offshore installations within its jurisdiction to be certified as fit for purposes specified, by independent organisations authorized by them and designated Certifying Authorities. A Certifying Authority is appointed by an Owner or Operator, and empowered to issue Certificates of Fitness when satisfied that the Regulations have been complied with.

Now legislative principles similar to those applied in the United Kingdom have been introduced by a number of countries and, Certifying Authorities or Verification Agents, for example Lloyd's Register and other Ship Classification Societies are recognised by the Canadian, Dutch, Eire, Danish, Indonesian, New Zealand, USA, South African and Australian Governments. Certification issued by Lloyd's Register (LR) is acceptable to many other governments throughout the world which do not have detailed requirements in support of their legislation. In Norway, LR is recognised by the Norwegian Petroleum Directorate and the Norwegian Maritime Directorate.

A Certifying Authority, or CA for short, is therefore that organisation or person contracted by an owner/operator and recognised by a government to issue Certificates of Fitness for offshore installations to be installed and/or operated within that government's area of jurisdiction.

This paper will examine the legislative requirements to be met and the activities to be undertaken by Lloyd's Register in their capacity as the appointed Certifying Authority to enable it to issue a Certificate of Fitness for the Hibernia installation.

CERTIFICATION REQUIREMENTS

For an offshore installation to commence production within Canadian waters the operator is required under the Newfoundland Offshore Petroleum Production and Conservation Regulations to have a Production Operations Authorisation. In the case of the Hibernia Project this would be issued by the Canada - Newfoundland Offshore Petroleum Board. A pre-requisite of the Production Operations Authorisation is for a valid Certificate of Fitness, issued by a Certifying Authority to accompany the application.

Before a Certificate of Fitness may be issued under the terms of the draft Canada Certificate of Fitness Regulations, the Certifying Authority must be satisfied that the following objectives have been met:

1. The installation is designed, constructed, transported and installed or established in accordance with the appropriate sections of the following regulations (also currently in draft form).

    a) Canada Oil and Gas Installations Regulations

    b) Canada Oil and Gas Production and Conservation Regulations

    c) Oil and Gas Occupational Safety and Health Regulations

    d) Canada Oil and Gas Drilling Regulations

    e) Canada Oil and Gas Diving Regulations

    In this case, for Hibernia it is the provincial equivalents of b, c, and d which will be used.

2. The installation is fit for the purpose for which it is to be used and can be operated safely without polluting the environment.

3. The installation will continue to meet the requirements of (1) and (2) above for the period of validity of the Certificate of Fitness if the installation is maintained in accordance with inspection, maintenance and weight control programs submitted to and approved by the Certifying Authority.

4. It has carried out the requirements described in the scope of work approved by the Chief Conservation Officer of the Canada -

Newfoundland Offshore Petroleum Board.

For the CA to fulfil its obligations the person/organisation applying for the certificate must:

a) Provide the Certifying Authority with all the information it requires.

b) Carry out or assist the Certifying Authority to carry out every required inspection, test and survey.

and

c) Submit inspection, maintenance and weight control programs for approval.

SCOPE OF WORK

The Certifying Authority's scope of work for the Hibernia Project has been reviewed and accepted by the Chief Conservation Officer of the Canada-Newfoundland Offshore Petroleum Board. This work focuses on performing design appraisals on submitted documentation and surveying activities on those aspects of design and construction which impact on the general integrity of the platform and its associated export pipelines and offshore loading systems. These activities shall be with regard to general safety aspects and the avoidance of unintended release of contaminants to the environment by failure of the facilities, for example by a leakage resulting from corrosion. The general safety aspects to be considered include the following:

- Structural designs being suitable for applied loads
- Plant / system designs for safe operations
- Fire and gas detection and alarm systems
- Fire fighting / protection systems
- Emergency escape / Life saving appliances
- Helideck arrangements
- Process and emergency shut-down (ESD) systems
- Relief, blowdown and flare systems
- Blow out preventers / integrity of wellhead connectors

- Wellheads / christmas trees and down-hole safety valves
- Ventilation / pressurisation systems

The draft regulations further require the scope of work for the Certifying Authority to confirm that:

(1) the environmental criteria and assumed loads for the installation are correct.

(2) that the safety analysis identifies potential hazards, and the steps that have been taken to eliminate them or reduce to acceptable levels their consequences with regard to life and the environment.

(3) construction and installation have been carried out using the approved specified materials and conform to the specifications and design drawings.

(4) the operations manual meets the statutory requirements.

Within the requirements of the draft regulations it is incumbent on the operator to use a quality program which satisfies the Canadian Standards Association Quality Program Standards contained in the CSA Z-299 series. The Hibernia management have confirmed their intention to require all major contractors, sub-contractors and suppliers to develope, establish, and implement such a program and Lloyd's Register have accepted such an approach as the basis for their activities for certifying the Hibernia installation. The quality plans for each phase or activity will be reviewed by the Certifying Authority to establish the levels of its involvement in design appraisal and surveillance during the procurement, construction and installation phases of the project.

This quality systems approach to project management is essential to ensure that traceability is maintained; that design, specification and regulatory requirements are met and that the installation is fit for its intended use. Further more "getting it right" first time will keep schedule and budget on target. It will more than ever require all parties to appreciate and fulfil their responsibilities. The requirements of the quality plan, quality control procedures and work instructions must not only be drawn up and placed in a manual, but be implemented and regularly checked to verify their implementation in all areas associated with the work e.g. in the office, in the works, in the stores, on the site.

METHOD OF EXECUTION

Certification for Hibernia will be divided into four main phases of work, namely design appraisal, procurement, surveying at the onshore and deep water sites and lastly surveying activities offshore.

DESIGN APPRAISAL

We turn first to design appraisal. This is performed on the basis of a review and audit of the designers' basic principles, methodology, analysis and calculations. The review concentrates on approving the overall design concept whilst the audit establishes that all design cases have been covered in a satisfactory manner. Selected numerical checks of the design calculations and a number of independent calculations are also carried out to confirm compliance with the regulations and specified codes.

The areas to which this is applied include the gravity base structure, topside structure, topsides systems, crude export loading lines, and offshore loading systems.

The acceptance of the environmental criteria is fundamental to the overall design of an installation and Lloyd's Register will review the data submitted and compare this with our-in house data.

Control of the design appraisal is achieved through a document register. The main design contractors send us their list of documents and we indicate those to be forwarded for appraisal. Our job is made easier when documents are submitted in coherent packages so that we do not cause delay by having to keep on requesting additional information.

A comment response sheet (CRS) is issued to the owner when the review of a design submission is completed. This CRS advises the status of the documents received e.g. Approved, Approved with Comments, Noted for Information, etc., and the document register is updated to reflect the current status.

Following the owner's action on those comments requiring attention, the owner will either resubmit documents or clarify the basis of their earlier submission.

A document will have considered to have completed the review cycle when its status, as shown on a CRS is either "Approved" or "Noted" and no further comment is required.

The objective of the CA design review is to confirm acceptance of the completed design at "Approved for Construction" stage when it has completed the full design cycle including all the engineering and quality checks by designers and owners and both parties consider (agree) the design codes, specifications and regulatory requirements have been met. It is the documents reflecting that status which are to be submitted for CA appraisal.

PROCUREMENT

Now we move on to Phase Two, Procurement. Just as design appraisal started with a review of the document register, so procurement starts with a review of the procurement register. The review will indicate those critical items for which scrutiny of documents will be required. This scrutiny of documents will follow the same procedure as that for the design appraisal documentation. In addition to this, vendors works for selected items will be subjected to periodic visits by LR surveyors. The purpose of these visits is to confirm that the purchaser is adequately monitoring the activities of his suppliers and that statutory requirements are being met.

Where a pre-inspection meeting is attended by the Certifying Authority, proposed visits will be indicated on the quality plan. Progress meetings with the Owner may also indicate the need for further attendances, these would be agreed with the owner and the supplier notified.As well as carrying out selected surveys and audits during the manufacturing schedule, the surveyor may attend the purchaser's Quality System Audits as an observer.

The surveyor will report any deviations from the agreed purchaser's or vendors' quality plan affecting the statutory acceptance by issuing a Non-Acceptance Note, or non compliance report. This will be cancelled when the agreed corrective action(s) have been taken.

SURVEYING AT ONSHORE AND DEEP WATER CONSTRUCTION SITES

During the third phase, namely construction at the onshore module and gravity base drydock and deep water sites the Certifying Authority will again be active ensuring that the Owner's or contractors' project specific quality plans are effectively implemented and satisfy the regulations.

At the start of site activities attendance by LR will be at a high level to review and monitor this implementation of the systems and procedures. There will be a similar high level of attendance at the end of the schedule to check completion of that phase of activity.

As an example of the areas of interest during the construction of the Gravity Base Structure (GBS), the certification process will be concerned with material identification and storage, the correct use of formwork, placement of reinforcement and the position, protection and support of pre-stress ducts and anchorages. Trial mixes of concrete are to be tested to prove the batching plant calibration, batching operations are to be sample tested in accordance with correct procedures and cold weather precautions are to be followed. Correct procedures are to be followed during the placement of concrete, curing, stripping of shuttering, handling of pre-stress cables during placement in the ducts, application of required corrosion protection measures; to ensure the required elongation is achieved and the tendon grouting procedures are adhered to.

Site surveillance visits will monitor the steel fabrication of modules, sub-assemblies and steel work in the GBS (with particular regard to connection of items to the concrete structure). This will address documentation for material control, welder qualifications, welder identification controls, the weld quality record system, and testing proposals and test reports.

The assembly, outfitting, installation, and completion and commissioning of the GBS, and topsides will be subject to surveillance and relevant tests will be monitored or witnessed. The commissioning function tests of interest are for Main and Emergency Electrical Power, High and Low Voltage Distribution, Rotating Machinery (e.g. diesel engines, gas turbines, compressors, pumps), HVAC systems, ESD and Depressurisation systems, Fire and Gas Detection systems, Active Fire Fighting systems, Well Control Equipment, Drilling System running gear and Lifting Appliances.

SURVEYING DURING OFFSHORE INSTALLATION

The fourth phase will be the transportation to and installation at the offshore location. Whilst transportation is primarily the responsibility of the marine warranty surveyor, as Certifying Authority, LR will need to be satisfied that no excessive loading or damage has occurred during the tow and ballasting down on location. The skirt penetration, grouting and completion of ballasting will be monitored to ensure the anticipated integrity and on bottom stability are achieved. Any outstanding work for completion prior to issue of the Certificate of Fitness will continue to be monitored and identified tests witnessed. The acceptance of the fire and gas detection systems, fire fighting systems and life saving appliances will be completed at this stage.

OPERATIONS MANUAL

Approval of the Operations Manual by the Certifying Authority is a requirement and this will be reviewed for completeness of content, cross-referencing to any other relevant documents (e.g. Operating Manuals for equipment). From a CA point of view the objectives of the manual are essentially fourfold; firstly to provide a concise description of the installation, its utilities and facilities; secondly to draw attention to all essential information for ensuring safety of persons and the safety and integrity of the installation; thirdly to provide a concise and non-ambiguous ready reference, supplying an overall index to the available information on the platform and lastly to provide guidance and instructions for necessary actions relating to overall aspects of the installations safety.

Details of the regulatory requirements are given in Part IV of the Canada Oil and Gas Installations Regulations.

SAFETY ANALYSIS

The CA's scope of work approved by the Chief Conservation Officer requires it to determine that the Safety Analysis meets the requirements of the Installation Regulations. The concept safety study as defined by the regulations will be reviewed with particular attention to the Hazard Analysis, Hazard and Operability and Risk Analysis studies and concluding report.

As many will be aware the Cullen report, which looked into the Piper Alpha disaster, has made strong recommendations for the need for a comprehensive safety assessment to be carried out for all installations in the North Sea and it is commendable that such considerations are included in the regulations applicable to Hibernia.

INSPECTION, MAINTENANCE AND WEIGHT CONTROL

Prior to the issue of a Certificate of Fitness the programmes to be implemented for inspection,maintenance and weight control are to be submitted for approval by the Certifying Authority. These programmes are to ensure that if correctly implemented the installation may continue to meet the requirements for the period of validity of the Certificate of Fitness.

CERTIFICATE OF FITNESS

Once all the requirements as outlined have been met a Certificate of Fitness may be issued for a period up to five years and will be subject to satisfactory surveys during that time.

It is anticipated that, as is normal practice on offshore projects, a phased certificate will be issued, initially to permit use of the installation for accomodation purposes only. As drilling and production facilities are completed and commissioned to the satisfaction of the CA Surveyors, so any limitations imposed will be withdrawn. Thus these facilities may be brought into use once any other aspects of the production operations authorisation are satisfied.

LLOYD'S REGISTER'S ORGANISATION FOR HIBERNIA

The management and administration of the Certifying Authority's obligations for Hibernia is the responsibility of the appointed project manager, currently based in the Montreal project office. In this capacity he will act as the formal point of communication between Lloyd's Register and the Operator and will liaise with the government authorities through the operator.

The project management organisation charts are shown in figures 1, 2, 3, and 4 and from these it can be seen how the different specialist departments within LR are or will be involved in the certification activities of the project.

The management of offshore projects falls under the Field Services Department of the Offshore Division which in turn is one of three main divisions within the corporate organisation of Lloyd's Register. This relationship and that of the service groups are illustrated in figures 5 and 6.

Surveillance at fabrication sites, sub-fabricators, and vendor's works is carried out by surveyors from offices local to the work. They have a functional line direct to the project manager while retaining their line, management through the country and regional management structure to the Headquarters management.

The control and audit of all the work is based on the requirements of the LR Corporate Quality System. Lloyd's Register is totally committed to the concept of quality assurance and has implemented a quality system based on the international standard ISO 9001. The compliance with the requirements of this are mandatory throughout LR and all Divisions, Regions and Offices have organisation and procedures manuals and issue work procedures and instructions with respect to the work undertaken. This applies to 1600 surveyors based in 280 offices in 100 countries covering a wide range of marine, industrial and offshore services to clients. It can therefore be appreciated that LR has a good grasp of difficulties that may be encountered initiating a quality system, and are able to offer a degree of help and understanding to our clients in developing their own QA programme.

The Offshore Division procedures manual details responsibilities and requirements for the quality plan; and for procedures, guidance notes and work instructions to be developed and implemented in conjunction with specific contract requirements on each offshore project. The applicable guidance notes and work instructions are issued to departments and local offices when notifying them of their involvement in a project.

The effective implementation of the quality system is subject to both internal and external audits, and with respect to Offshore Division a number of external audits have been undertaken by Government authorities.

For completeness the corporate quality organisation is shown on figure 7. The direct communication link between the divisional and regional quality officers to the corporate quality Committee through the Corporate Quality Manager and Director is illustrated.

CONCLUSION

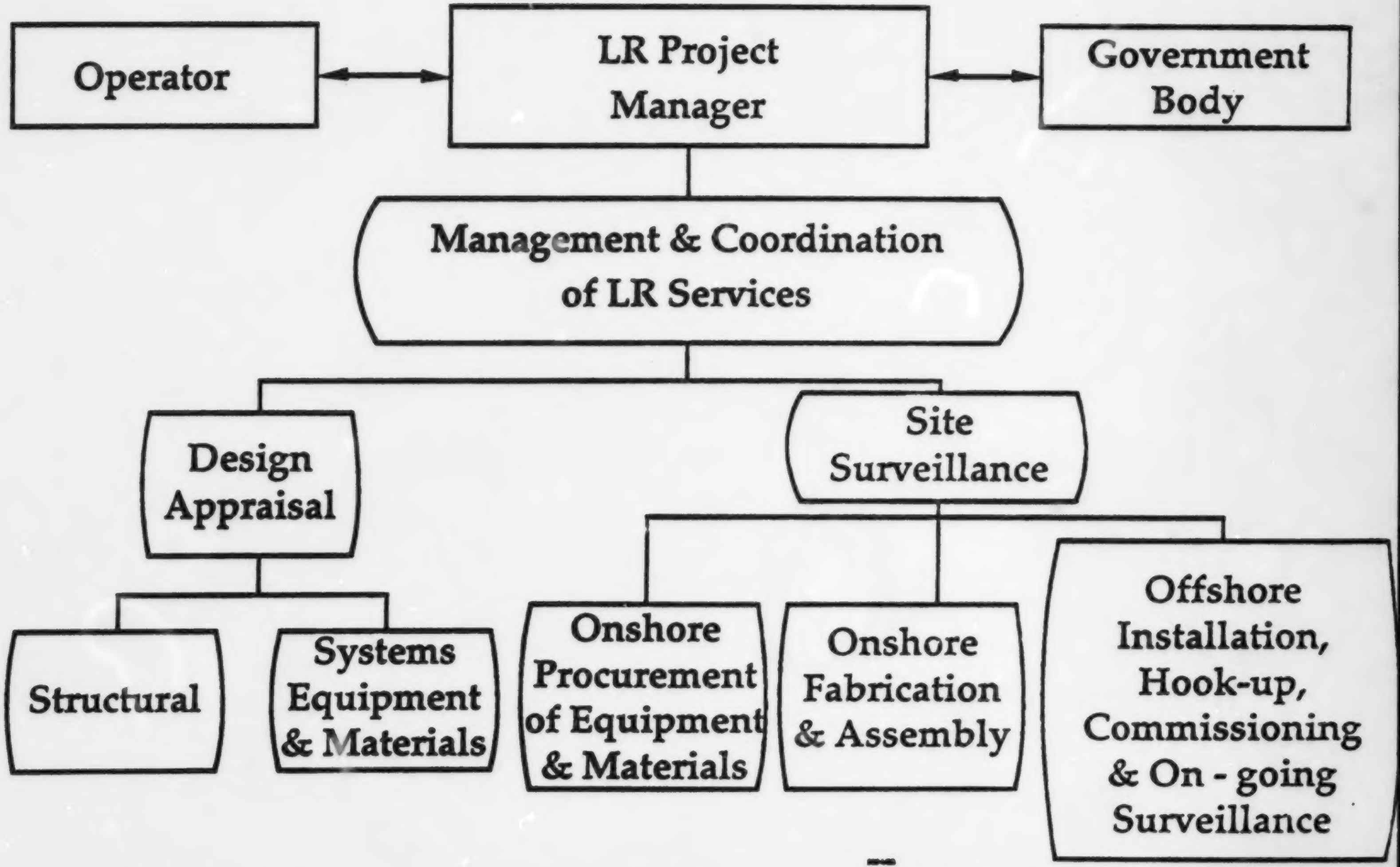
The requirements for certification and role of Lloyd's Register as the Certifying Authority have been described in some detail. The manner in which LR will perform its work on Hibernia is also described.

In the fulfilment of its obligations as Certifying Authority on Hibernia, it is our objective to work with the Operator, and the Governmental Agencies to ensure the applicable regulations are met, that the installation is fit for purpose, and that it can operate safely.

ACKNOWLEDGEMENTS

The author would like to thank the Hibernia Management and Development Company and Lloyd's Register for permission to publish this paper. The assistance and advice of friends and colleagues during the preparation of this paper is also gratefully appreciated.

Project Management Organisation


Operator
LR Project Manager
Government Body
Management & Coordination of LR Services
Design Appraisal
Site Surveillance
Structural
Systems Equipment & Materials
Onshore Procurement of Equipment & Materials
Onshore Fabrication & Assembly
Offshore Installation, Hook-up, Commissioning & On - going Surveillance

Lloyd's Register

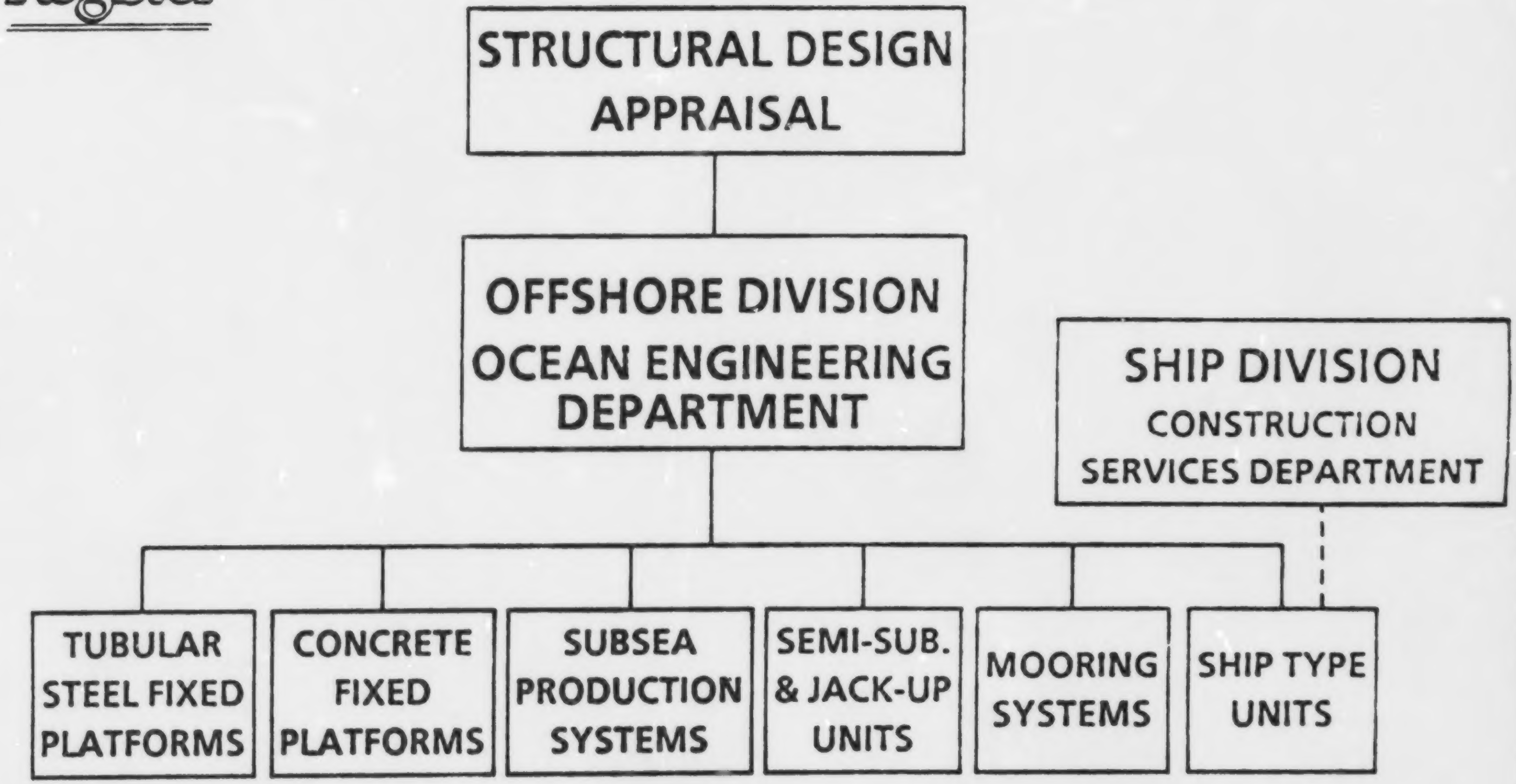
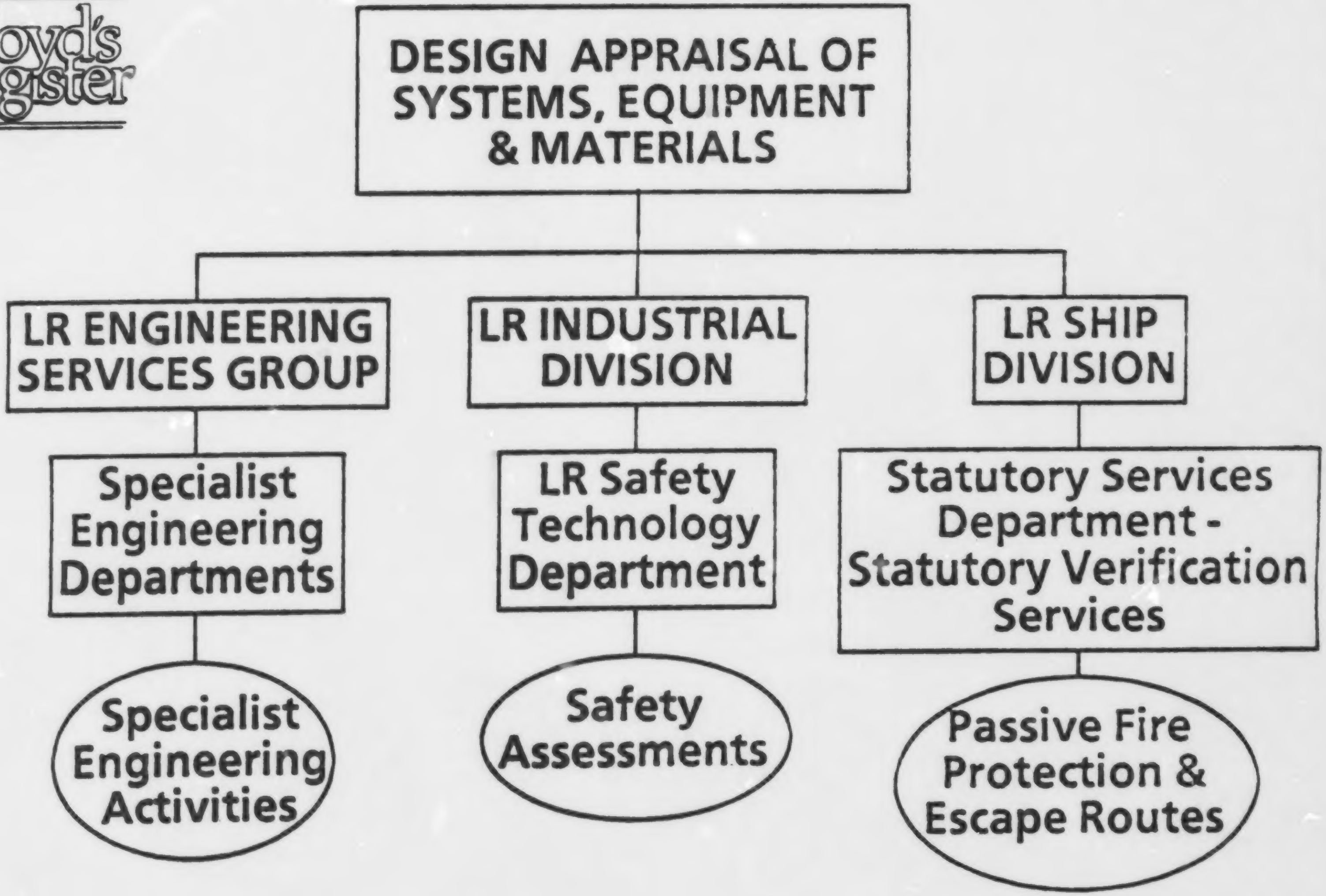

STRUCTURAL DESIGN APPRAISAL
OFFSHORE DIVISION OCEAN ENGINEERING DEPARTMENT
SHIP DIVISION CONSTRUCTION SERVICES DEPARTMENT
TUBULAR STEEL FIXED PLATFORMS
CONCRETE FIXED PLATFORMS
SUBSEA PRODUCTION SYSTEMS
SEMI-SUB. & JACK-UP UNITS
MOORING SYSTEMS
SHIP TYPE UNITS

FIGURE 2

Lloyd's Register



DESIGN APPRAISAL OF SYSTEMS, EQUIPMENT & MATERIALS

LR ENGINEERING SERVICES GROUP

Specialist Engineering Departments

Specialist Engineering Activities

LR INDUSTRIAL DIVISION

LR Safety Technology Department

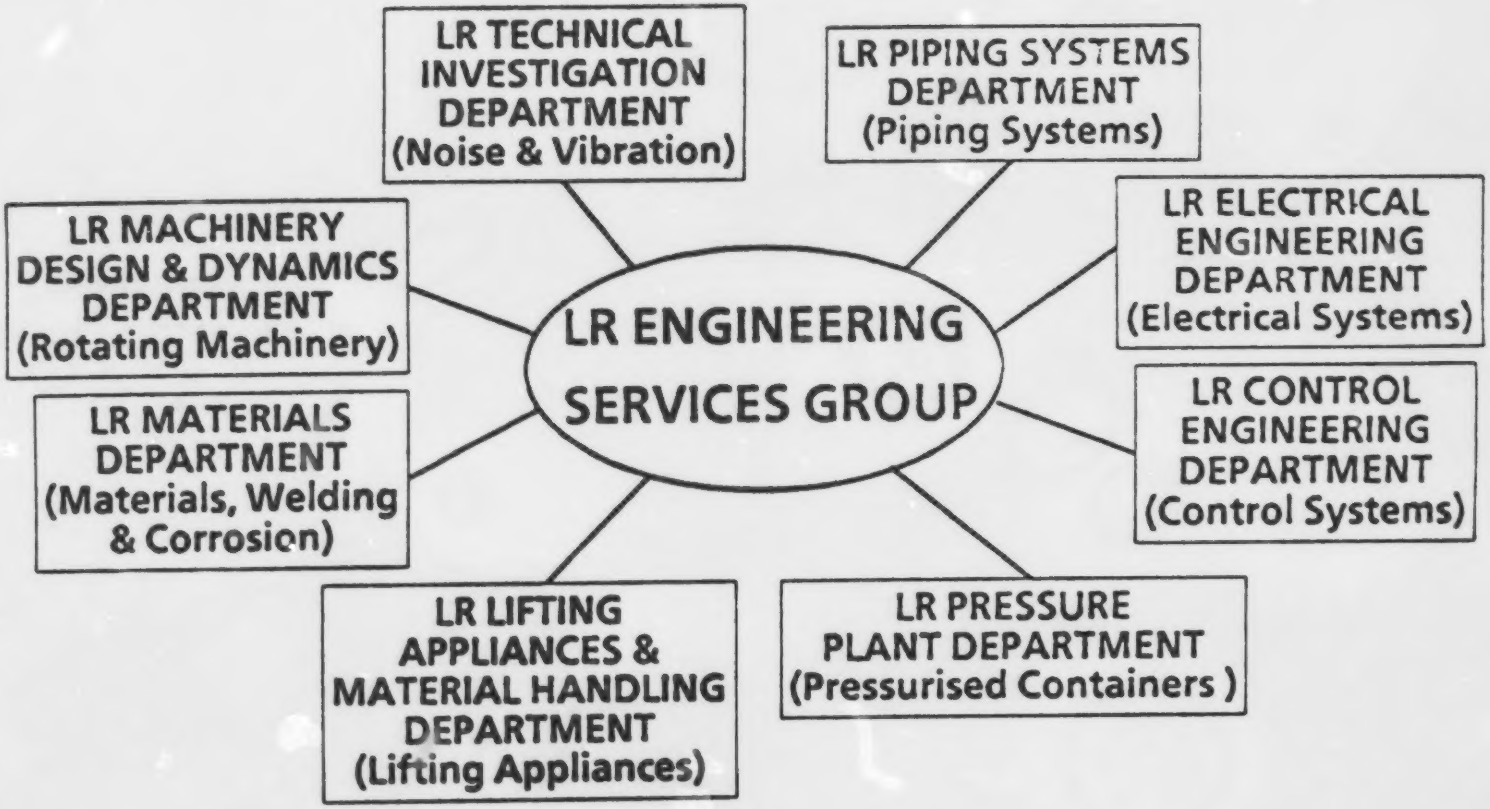
Safety Assessments

LR SHIP DIVISION

Statutory Services Department - Statutory Verification Services

Passive Fire Protection & Escape Routes

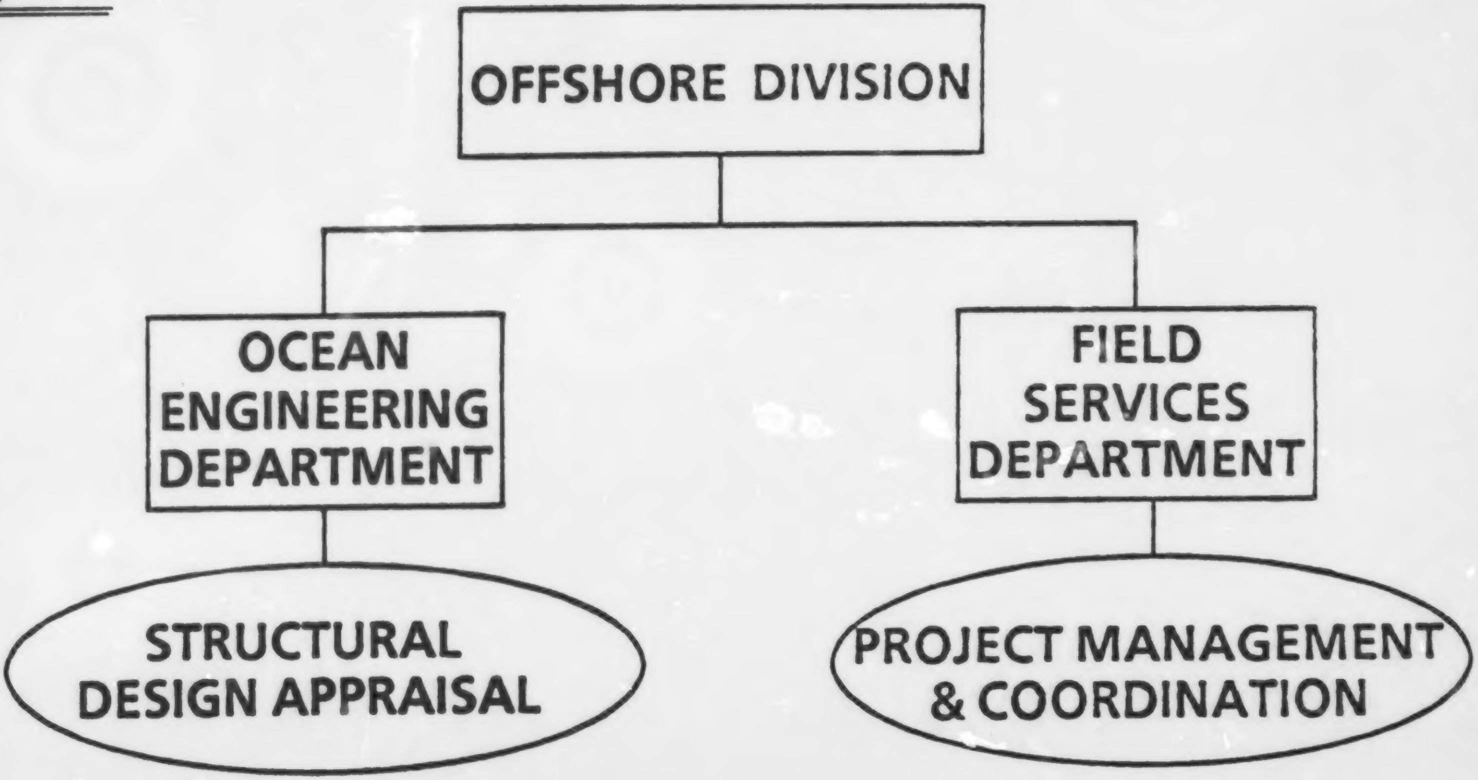
FIGURE 3



LR ENGINEERING SERVICES GROUP
LR TECHNICAL INVESTIGATION DEPARTMENT (Noise & Vibration)
LR PIPING SYSTEMS DEPARTMENT (Piping Systems)
LR MACHINERY DESIGN & DYNAMICS DEPARTMENT (Rotating Machinery)
LR ELECTRICAL ENGINEERING DEPARTMENT (Electrical Systems)
LR MATERIALS DEPARTMENT (Materials, Welding & Corrosion)
LR CONTROL ENGINEERING DEPARTMENT (Control Systems)
LR LIFTING APPLIANCES & MATERIAL HANDLING DEPARTMENT (Lifting Appliances)
LR PRESSURE PLANT DEPARTMENT (Pressurised Containers)

FIGURE 4

Lloyd's Register



OFFSHORE DIVISION

OCEAN ENGINEERING DEPARTMENT

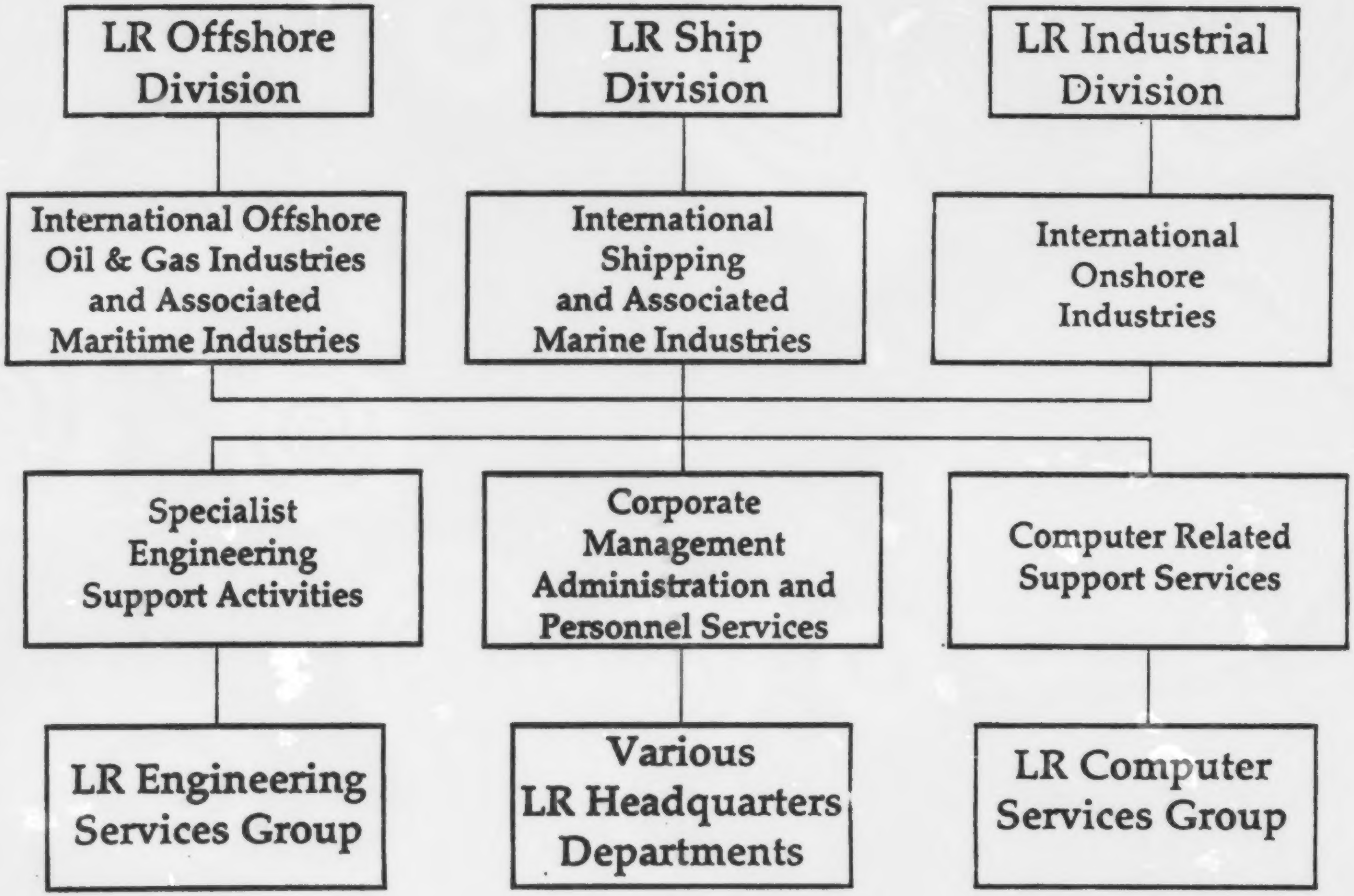
FIELD SERVICES DEPARTMENT

STRUCTURAL DESIGN APPRAISAL

PROJECT MANAGEMENT & COORDINATION

FIGURE 5

LR Corporate Organisational Structure



LR Offshore Division

LR Ship Division

LR Industrial Division

International Offshore Oil & Gas Industries and Associated Maritime Industries

International Shipping and Associated Marine Industries

International Onshore Industries

Specialist Engineering Support Activities

Corporate Management Administration and Personnel Services

Computer Related Support Services

LR Engineering Services Group

Various LR Headquarters Departments

LR Computer Services Group

Quality Assurance Organisation

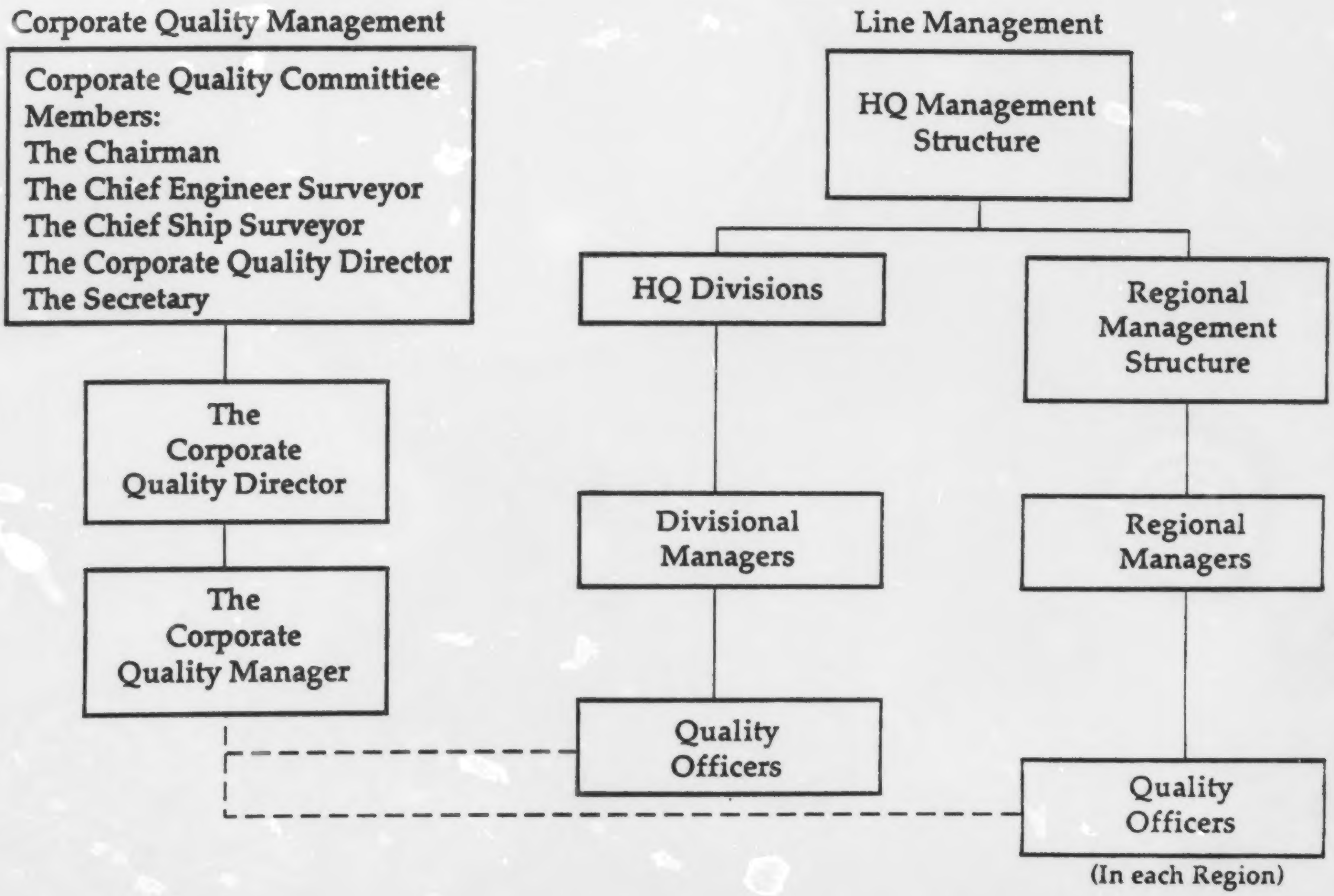

Corporate Quality Management
Corporate Quality Committiee
Members:
The Chairman
The Chief Engineer Surveyor
The Chief Ship Surveyor
The Corporate Quality Director
The Secretary
The Corporate Quality Director
The Corporate Quality Manager
Line Management
HQ Management Structure
HQ Divisions
Regional Management Structure
Divisional Managers
Regional Managers
Quality Officers
Quality Officers
(In each Region)

FIGURE 7

"The Demands and Effects of the Hibernia Project on Newfoundland"

Notes For an Address

by

Bob Kimberlin
President
Hibernia Management and Development Company Ltd.

Opening Luncheon
NOIA Conference 91

June 17, 1991

Thank you Rob for your kind introduction.

Ladies and gentlemen:

There is no longer any question about it. Not only is the Hibernia project a reality, but it is now being described as one of the bright spots in the national economy. Who would have thought that Newfoundland could lead Canada out of recession?

Over the past few months it has been very gratifying to read stories in the local papers with headlines such as:

"Newfoundland companies cashing in on Hibernia"

"Carbonear firm reaps benefit from Bull Arm contract"

"250 Hibernia sub-contracts soon to be let"

There is no question that Hibernia is one of the most exciting, most challenging and most important projects in Newfoundland's history. Throughout the life of the project there will be significant employment and business opportunities created by the demand for products, equipment and services.

Analysis of Newfoundland's economic performance in the first quarter of 1991, published by the provincial government, indicates:

The signing of the agreement on September 14, 1990 to develop the Hibernia offshore oil field, and subsequent project development, was a positive influence on the Newfoundland economy ...

Hibernia activity to date has been significant. To the end of April our company has spent about $170 million, 55% of which has been directly in Newfoundland.

Approximately 1200 men and women are employed by us and our contractors, with most working in either St. John's or Bull Arm.

Whether the activity associated with the project is significant in economic terms may be a matter of debate in some circles. Some business sectors, engineering and construction for example, are benefiting quite a lot. Others, such as retail, may not yet be feeling any substantial impact.

However, I have absolutely no doubt that the biggest impact is the psychological boost it has given everyone here. Hibernia has given the local business community something to get excited about and something that enables them to focus their attentions.

As it progresses, this project will continue to hold the promise of rewarding business opportunities for many entrepreneurs. But, I believe that the true measure of this project will not be found only in the economic indicators. We need to look elsewhere.

For example, at this year's offshore petroleum exhibition there are 416 booths representing some 320 companies. That is a significant increase over the 100 booths at last year's show. The highest previous involvement was 258 exhibitors at the 1985 show.

Similarly, I understand that membership in NOIA has grown substantially this year. NOIA has accepted 100 new members bringing total membership to about 264 companies.

In September of 1991, we will be awarding the wellhead module contract which is valued in the 100's of millions of dollars and will employ many additional men and women.

With that said, however, Newfoundland's economy is struggling in other areas, notably the fishing industry.

In some respects, this puts more pressure on Hibernia -- pressure to be the major influence in the Newfoundland economy. Expectations have been high ... jobs, contracts and prosperity for everyone.

But Hibernia is no panacea. It is much, much more than jobs and contracts for a few years. As I have said so many times, Hibernia is more than a construction project. We plan to be in production for about 20 years after the construction phase.

For this reason, we should also consider other aspects of Hibernia. Of course I'm referring to the long term value of the project ... the real importance of Hibernia for Newfoundland, for Newfoundland's people and for the business establishment.

I would like to focus on this theme ... the less tangible, but perhaps more important long term impacts of Hibernia.

We hear a great deal about the global economy and the need to be competitive. We also hear a lot about the fact that this is the information age and that innovative technology is one of the biggest areas of opportunity.

What does this mean for Newfoundland?

Many believe that Newfoundland cannot compete in the global marketplace ... that manufacturing in this province will never be a significant economic reality.

I was surprised to hear that there were hundreds of manufacturing companies in Newfoundland, most of those involved in the non-resource based sector.

As well, this manufacturing industry generates some $600 million in GDP and provides employment for more than 20,000 workers. I'm told, this seemingly little known industry produced manufacturing shipments with a value of $1.4 billion in 1989.

It is evident today that the road to a healthy economy is through manufacturing. Producing value added products can provide Newfoundland with the greatest direct and indirect economic benefits.

In many respects, Newfoundland's offshore oil industry has been partially responsible for the growth that has been achieved in this sector.

Offshore activity over the past 15 to 20 years, and the discovery of Hibernia and other commercially viable oil fields in particular, has spawned tremendous interest in the development and commercial application of innovative technologies. Many of those companies had their sights set on the Hibernia project at one time, and many of them will do business with us. Other companies have developed and are successfully marketing a variety of new products all over the world.

Newfoundland companies are successfully breaking into the aerospace and defense industries - two of the most challenging and difficult areas of business opportunity.

Newfoundland companies are developing computer software and hardware for a variety of practical commercial and industrial applications. Newfoundland companies, as you may be aware, have also developed quality expertise in a variety of marine related technical fields ranging from ice dynamics to ground wave radar systems.

You may be interested in knowing that in the past 10 years, the number of companies involved in innovative technologies has grown from less than a dozen to approximately 60. Most of them are success stories that speak well of the creativity, technical expertise, business acumen and old-fashioned determination of some very talented entrepreneurs.

There is a tremendous amount of R & D activity going on here. Some is offshore related, and some is in a wide range of other fields.

The point I want to make here is a simple one. Newfoundland's economy is changing right under our noses.

The Hibernia project is stimulating some of this activity. But there is something else going on behind the scenes that is not quite as obvious.

One of the many factors contributing to a successful high tech and non-resource based manufacturing sector is the tremendous importance of quality.

Many of you are aware, of course, that one of the requirements for doing most business with Hibernia is that contractors must establish formal Quality Assurance and Quality Control programs.

I addressed the graduating class at the Cabot Institute of Applied Arts and Technology last week.

One of the points I made is that their generation is one of the most highly educated in this province's history. Working with innovative entrepreneurs, they have been responsible for a great deal of this exciting activity. They have a quality attitude, a desire to do something different, to do it well and to be successful.

They have seen the potential for opportunity and said: "We can do that here."

Interestingly enough, while many of these businesses may be able to provide some of the products and services required for the Hibernia project, for the most part their business success has not been dependent on any one project.

These companies are pursuing markets wherever they are to be found. They are developing their products and business strategies based on the needs of a far bigger market than the Hibernia project. They are clearly focused on the global marketplace and successfully putting technologies, resources and strategies in place to do the job.

Innovative entrepreneurs know that future prosperity and growth opportunities in Newfoundland will not be tied to the traditional resource industries.

The reason for this is very simple. There are only so many fish and so many trees and other resources that can be harvested annually. As innovative and competitive as we may be, or could become, there is a limited amount of economic activity which can be derived from these finite resources.

When the resource is information and brain power, and you are pursuing world markets, there are no such limits. This is the economic resource base of the future that Newfoundlanders have already begun to successfully tap.

In my own experience as an engineer and manager on oil projects around the world, I know that technology is not limited by geography. In the coming decades, the winners will be those who capture the opportunities associated with innovative technologies.

In this sense, the Hibernia project is more than a resource industry. It is complex and challenging, demanding the very best of the men and women, contractors and suppliers who will be associated with it. I hope that one of the indirect benefits of our Project will be that the attitudes of people toward work, entrepreneurship, and quality will be stimulated.

Hibernia can be a training ground for Newfoundland ... an opportunity to develop skills and entrepreneurial capabilities that are second to none.

Ross Perot, the billionaire Texan who was once the biggest shareholder in General Motors Corporation, was very blunt in a recent speech in which he offered a rather frank assessment of what ails the American economy. He said:

> "There is no substitute for being the best at what you do. We are so happy being mediocre it makes me sick."

Mediocrity is at the heart of much that is wrong with the entire North American economy.

Canadians prospered for the first 100 years or so of this country's history on the tremendous wealth generated by harvesting raw natural resources. For the next twenty or thirty years we lived on the credit that those resources provided.

Our resources are becoming scarcer. Other countries have seized opportunities, created largely by our own mediocrity, to develop technological excellence and leadership in manufacturing. The lesson is clear. We have no choice but to move in the same direction.

If the growth and success of the 60 or so companies involved with innovative technologies here in Newfoundland are any indication, then we can probably assume that the trend is reversing.

We can no longer afford to be mediocre about our resources, our environment, our skills and technologies, or about our ability to compete with the rest of the world. Mediocrity is out. Quality is in.

The new economic order in Newfoundland, to coin a now popular expression, will be built on the strength of a commitment to a new philosophy ... a new way of doing things.

In his book, A Commitment to Greatness, Richard J. Mahoney, Chairman and Chief Executive Officer of Monsanto Company, talked about the "three-pronged concept" which formed part of the transformation of that company from one "often dependent upon events beyond its control to one that had a substantial say in its own destiny".

The three prongs of the concept are:

- Stop doing what you can't do well.
- Do better what you do well.
- Start some new things for renewal and growth.

This is clearly an appropriate philosophy for any company, and one that I believe also suits Newfoundland.

The Hibernia project is very much a people project. The technological, environmental, and other challenges will be dealt with by people with one essential and common attitude - that 'good enough' is no longer good enough. Just as in the new global marketplace, second best simply won't cut it on the Hibernia project.

Hibernia is about people, men and women who have the skills and training to meet the demands of the project. I would also like to add to that point that we encourage and expect women to compete for those jobs and to make the Hibernia project a career choice.

We have done a number of things to encourage women to work on the project in both the construction and production phases, including the provision for facilities and separate living accommodations.

We also recognize that it is important to have women involved in non-traditional jobs. Our Hibernia scholarship program recognizes these needs and specifically addresses the issue of scholarships for women who are pursuing their education in petroleum-related fields.

We want good people, well trained for the work they are doing, and doing quality work.

The Hibernia project is about quality, demanding men and women who are not only skilled at their crafts, but who are dedicated to quality, and who can think and solve problems.

Quality work will mean a safe project and this is the only kind of project we will operate on the Grand Banks.

I talked about the manufacturing and innovative technology sectors, a few moments ago. In these sectors the principles of quality have been the most evident and have achieved the most dramatic results.

But the principles of quality and the rejection of mediocrity are important, as well, to more than the technical and high profile export industries. They are important for every social, economic and political endeavour and for every business and organizational initiative.

As I said, Newfoundland's offshore oil industry has been at least partially responsible for the transformation that is taking place.

We must get the Hibernia project right the first time. We must prove that Newfoundland and Newfoundlanders can do it ... that we are and will continue to be players in the global economy.

To conclude then, the real demands and effects of Hibernia are not the immediate ones, even though they will be significant. The true value of Hibernia will be realized by your sons and daughters.

Thank you.

SPEAKER : PIP RUDKIN

COPMANY : ATLANTIC AIRWAYS

LOCATION: ST. JOHN'S, NEWFOUNDLAND

TOPIC : REMOTE SENSING SYSTEMS FOR INTEGRATED OFFSHORE ENVIRONMENTAL MONITORING

BIOGRAPHY: *Pip has been involved in ice data collection and management for over ten years, he has participated in all aspects of offshore environmental programs, from rig observer to project manager. In this period he has published several papers on ice detection and surveillance, and has been a speaker at several international symposiums, including: The 21st Symposium on Remote Sensing, Polar Tec 88, and World Symposium on Fishing Gear and Vessel Design. For the last five years, Mr. Rudkin has been employed by Atlantic Airways, St. John's, as the Manager of Ice and Environmental Services. Over this period he has been involved in several studies on the effectiveness of radar systems to detect ice targets. At present, he is responsible for the management of an integrated ice management service which is under contract to BP Resources Canada.*

REMOTE SENSING SYSTEMS FOR INTEGRATED OFFSHORE ENVIRONMENTAL MONITORING

P. RUDKIN

ATLANTIC AIRWAYS

ST. JOHN'S, NEWFOUNDLAND, CANADA

Abstract

Any project the size of Hibernia raises concerns about the effects on it of the surrounding environment. Nowhere is this more true than with the hostile environment of the Grand Banks, where icebergs and possibly heavy pack ice present a threat to both loading facilities and tankers. High seas and poor visibility in winter also will play a major role in tanker schedules, and oil pollution from any source likely will be blamed on the Hibernia development. While these problems are very real, their effects can be minimized by the use of integrated remote sensing technology.

Remote sensing can be placed in two main categories, spaceborne and airborne. Spaceborne remote sensing from satellites equipped with imaging radar and thermal and optical sensors is capable of providing information such as ice coverage, sea state, and ocean temperature over a very large area. However, the resolution of the sensors is too coarse to supply the detail required to effectively manage the environment. A secondary problem with space sensors is that they often do not provide the information within the time frame required. These problems aside, satellite sensors in future will play a leading role in long term planning of environmental management.

Aircraft remote sensing provides the same sensor arrays as spaceborne. However, operating at a lower altitude, airborne sensors provide a far higher image resolution. Data on specific areas of interest can be provided in near real time, which is of much greater value in the day to day planning and management of operations.

In any project, cost effectiveness is of the highest concern and remote sensing, whether space or airborne is a major cost item. To justify this expense in the airborne case will require the integration of several sensors onto a single platform. These sensors will have to provide data in a format compatible with spaceborne sensors and also provide information on all aspects of environmental concern.

Environmental Considerations, with respect to the Hibernia Offshore Development.

The Hibernia oil field lies in the North Atlantic, some 180 nautical miles East of St. John's, Newfoundland. This area, known as the Grand Banks, is as infamous for it's extreme environmental conditions as it is famous for its rich fishing grounds. Serious oil and gas exploration in the area has been ongoing for the past 10-15 years. Over this period the various operators have implemented environmental programs which concentrated on collecting data on atmospheric and oceanographic phenomena at the well site, and also detection, monitoring and management of ice within a 30 mile radius of the well site.

These programs, while fairly successful, only concentrated on conditions directly surrounding and affecting the exploration platform. Despite this approach, over the years, some valuable data has been collected and some innovative ideas for data collection and management have been carried out that will make a lasting contribution to the environmental monitoring and management of the Hibernia project.

Several factors shape the environment around the Hibernia oil field, chief among these is the fact that the field lies within the southern extent of the marginal sea ice zone.

Pack ice can cover the Hibernia site from January to April, with total concentrations averaging 6 to 8 tenths of first year ice (0.5 - 1.0 m in thickness). Towards the later part of the ice season small floes of rafted first year ice exceeding 2 meters in thickness can be experienced. As is typical with ice coverage in the margin, pressure is not a problem due to the loose overall concentrations. Ice movement is of primary concern for oil operations in the margin. Large pieces of rafted ice can move in excess of 50 miles per day, and while this will have little if any direct effect on the GBS, the tankers and their loading facilities will have to be protected from the impact of fast moving ice. Pack ice coverage will also play a role in tanker routing and scheduling and will require a program of detection, monitoring and management.

Icebergs are present in the Hibernia area year round, with the major flux between February and June. The total number of icebergs crossing the Hibernia area vary from season to season. For example in 1981 no icebergs were reported, while in 1985 over 2,000 were detected (Report by the International Ice Patrol). Icebergs with a mass of 6 million tonnes have been measured, although the average mass runs around 100,000 tonnes, and while the GBS is designed to withstand iceberg impact, discretion would still dictate that these icebergs be towed or deflected to avoid direct impact as much as possible. As with pack ice the tankers and their support facilities will require direct action to protect them from the possibility of iceberg collision.

Past detection and monitoring of ice in the offshore has primarily relied on data from visual observations, and while there is no doubt that this is the most reliable method of observation, it is not very practical in an area where visibility is frequently below 5 miles and 60% of the spring time weather observations report visibilities below 1/4 of a mile. This single factor dictates the need for a reliable remote sensing system to detect and monitor ice conditions.

As if the environmental elements were not enough, Hibernia also lies in the middle of the transatlantic shipping routes and over one of the riches fishing grounds in the North Atlantic, making it one of the key targets of blame for any oil pollution detected in the area. With the renewed political interest in pollution of the oceans it makes both political and economic sense to be able to prove that the offshore industry was not the source of any pollution that may be detected. Also in light of the Exxon Valdezed experience it is both economically expedient and prudent to be able to respond to any accident that may occur regardless of source.

While these environmental factors appear daunting they are not insurmountable. However, a co-ordinated monitoring and management plan using the best combination of modern remote sensing techniques will be required by the Hibernia project.

As with most high tech products, remote sensing in all its forms is quite costly, so every effort should be made to evaluate the effectiveness of the sensor, it's required task, and how it can work to complement other sensors. The following discussion will cover various remote sensing techniques and sensors, with a view to suggesting an integrated sensor package to cover the various data requirements for the Hibernia development.

A General Overview on Remote Sensing

As mentioned above, remote sensing can be of two principle; spaceborne and airborne. Both types use similar sensors, but the coverage, resolution, and availability of data vary greatly between the two methods.

Generally, spaceborne sensors cover a larger area than airborne. However, their resolution is poorer, and the timely availability of their data is questionable. Most remote sensing satellites orbit the earth, so the user will only be able to get data for a specific area in a general time frame. Spaceborne sensors are usually mounted on multi-sensor satellites. To acquire data, the user must contact the operating authority and book the required time window, position, and sensor he or she wishes to use well in advance. There is also quite a large time lag between the sensor acquiring a specific image and the user receiving the same. Under certain conditions this is not a problem, however, it rules out many spaceborne sensors for real-time applications.

Airborne sensors are usually mounted on fixed or rotary wing aircraft. Their resolution is in general higher than that of spaceborne sensors and the timely availability of data is far superior, with many systems capable of providing near real-time data. The cost factor is higher with airborne sensors. However, by combining a range of sensors it is possible to provide data on many environmental parameters from a single mission. Thus by acquiring data for several applications at the same time the cost of an airborne sensor platform can equal spaceborne imaging for a single application.

Spaceborne Optical Sensors

There are several spaceborne optical sensors available such as Landsat TM and Spot 2. While the resolution of Spot imagery is a very high 10 meters, optical sensors in general are not too practical for an area with the fog and cloud coverage of the Grand Banks. There is also a considerable time lag between the image being taken, and its delivery to the end user.

Spaceborne Radar Sensors

At the time of writing there are no commercially available satellite radars. However, ERS 1 is due to be launched this summer. ERS 1 is a synthetic aperture radar satellite with a high resolution which should be capable of supplying quite detailed images of pack ice that could be useful in long range planning. Also due for launch soon is the Canadian RADSAT. This satellite will be placed in an orbit that will cover all areas of Canada and is designed to have a very high resolution.

Airborne Optical Sensors

As with spaceborne optical sensors, the primary requirement for airborne optical sensors is visibility. Having said that, there are some very good airborne optical sensors available. First amongst these is the original and still the most reliable optical sensor, the human eye.

Airborne Thermal/IR Sensors

Several types of thermal sensors are in use. One of the most common is forward-looking infrared (FLIR). These sensors record temperature differences and could be used to distinguish icebergs from vessels in poor visibility, or to detect oil floating on the surface of the ocean. IR sensors do not penetrate moisture very well which would limit their use somewhat, considering the persistence of fog on the Grand Banks. Having said that, some kind of IR capability would be useful when used in conjunction with other sensors.

Airborne Radar Sensors

There are several airborne radar sensors available, and each has its strong and weak areas with regards to environmental monitoring.

Side Looking Airborne Radar (SLAR)

SLAR was initially designed as an imaging radar (that is, a radar which produces a hard and/or soft copy picture) for land mapping and surveillance of international boundaries. It has been used over the years in a variety of applications: amongst them, ice surveillance, pollution monitoring, and oil spill mapping. SLAR radars generally have a resolution of around 40 meters and are capable of producing quite detailed maps of pack ice coverage. Their ability to detect and map oil spills and pollution is far superior to that of any other radar system. SLAR also has some capability for detecting vessels and larger icebergs. However, due to its small number of "looks", (the time the target is in the radar beam) point target detection is not one of SLAR's strong points.

SLAR also suffers from the same limitation that besets all side-looking, radars. That is, their optimum operating altitude is quite high, about 6,000 to 10,000 feet, which in the Grand Banks area is usually above the cloud ceiling, making visual confirmation of a target impossible. Also being side looking it can not be used to guide the aircraft and crew to a position to visually identify the target.

The ability to visually confirm the identity of a target is critical to the cost effective deployment of surface vessels engaged in ice management activities. As stated in the introduction, the Hibernia area not only lies in the southward flow of numerous icebergs, but also in an area of high density fishing activity. Radar returns from fishing vessels and medium to large icebergs are almost indistinguishable. This has resulted in a large amount of time being wasted by surface vessels having to confirm radar targets reported by SLAR-equipped aircraft engaged in tactical ice surveillance.

Synthetic Aperture Radar (SAR)

Working on a similar principle to SLAR, SAR is a very high resolution (around 6 meters) side-looking, imaging radar. Processed SAR imagery will produce very detailed pack ice charts, and will show radar targets of most small icebergs. However, SAR's optimum operating altitude is above 20,000 feet, which again precludes visual confirmation. A secondary consideration is that, at present SAR data requires a considerable amount of processing to provide full resolution images. Consequently it cannot be used in a real-time operation. This problem may not exist, however, by the time the GBS is in place, as real time processors are advancing rapidly.

SAR radar is also quite capable of showing many ocean features such as: wave height, current patterns, and upwellings. This data, if derived by satellite images which can cover a very large area, may provide some useful information to optimize vessel routing for tankers and support vessels.

Search Radar

Search radar's primary design is for anti-submarine warfare, the ability to detect a very small contact in a high sea state and guide the aircraft to that position for confirmation by visual or other means. Unlike SLAR or SAR, search radar is a rotating radar which looks through 360°. Most use a ground mapping mode which integrates numerous scans of a target to raise its return above the surrounding sea clutter. Search radar has been used successfully for ice surveillance on the Grand Banks for the past 5 years and has excelled in the detection and monitoring of small icebergs and bergy bits. The ability of search radar to map pack ice is well below that of either SLAR or SAR. However, it is capable of providing a near real-time ice chart showing the location of the ice edge and a general classification of ice types (thickness) and concentrations.

The optimum altitude for search radar is defined by the mission requirements and not the system design. That is to say, if long range detection is required, the radar is flown high, while if visual confirmation of a target is required, the radar is flown low. In both cases there is no detrimental effect to the imaging.

Data Requirements for Monitoring and Response.

There are two basic areas where remote sensing can assist the environmental management and response process. But before discussing appropriate sensors, we must establish what the data requirements will be.

1. Ice Monitoring and Management

Ice monitoring will cover two main areas, long range information for planning purposes, and closer range, tactical information. Long range information will consist of consecutive general data arrays showing pack ice distribution and thickness, and a general census of iceberg distribution and size. Tactical data will consist of more detailed information consisting of pack ice coverage, thickness and drift, along with iceberg position, size and drift.

2. Pollution Monitoring and Response

Pollution detection, while not a direct responsibility of the operator, can be accomplished in conjunction with general ice surveillance. Data on any pollution, whether oil or other, would be limited to its position and size, and the identification of any vessels in the immediate area. Pollution response on the other hand will require an accurate evaluation of the size, movement, and content of the spill.

To make the maximum use of remotely sensed information the data, whether raster or spatial, must be supplied in a format that is compatible for use in a multi-layered information system or GIS.

An Approach to Integrated Remote Sensing

The first step in this approach is to set in place a GIS system capable of manipulating and displaying all the required data. Actual environmental surveillance and monitoring would be broken down into two areas, long range planning data, and detection, monitoring, and surveillance of targets within the areas of probable risk (established from historical data for the area).

For long range data on targets outside the areas of probable risk, it will be sufficient to know their general position and track. This information would probably not require a dedicated airborne remote sensing platform, but could be supplied by a combination of shore based HF radar and SAR satellite images of opportunity (depending on their final resolution).

Tactical data could be supplied by a single multi-sensor aircraft, which would be equipped mainly for ice surveillance, but with the addition of dual-purpose ice/pollution sensors. The sensor array should be capable of operating at altitudes that allow visual confirmation of targets within the area of interest. Data would be collected in a digital format that would be compatible with the GIS. Allowances should also be made within the airframe to accommodate additional specific sensors on an as required basis.

CONCLUSIONS

At present it would appear that satellite-based SAR has the greatest potential of the spaceborne sensors. However, it is not possible to say how much effect this radar will have on any environmental monitoring program as there are just too many unknown factors at this time. It is clear, however, that some kind of airborne program will be required.

This program will concentrate on identification of targets already being tracked by other long range detectors such as spaceborne SAR or HF radar. In addition, it will provide detection of any targets which have escaped detection by these other means.

The system configuration should concentrate primarily on the reliable detection and tracking of icebergs and sea ice, and be capable of providing a response to any pollution problems that may arise.

Among the presently accepted sensors, search radar provides the best iceberg detection capabilities and is the only sensor that allows for operational identification of targets in poor visibility conditions. By linking the search radar to an onboard computer system it would be possible to provide near real-time digital data to an onboard GIS system. To cover potential pollution response it would be advantageous to have the airborne platform equipped with the capability of carrying an airborne IR line scanner. While this sensor would not be required on a day to day basis it could be mounted quickly and be integrated into the radar data to provide useful information on spill size and thickness.

SPEAKER : ***JOE RYAN***

COMPANY : ***SIGMA ENGINEERING LIMITED***

LOCATION: ***ST. JOHN'S, NEWFOUNDLAND***

TOPIC : ***ICEBERG DETECTION USING MICROWAVE RADAR***

BIOGRAPHY: *Mr. Ryan was born in Newfoundland. He received a Bachelor's Degree in Engineering from Memorial University in 1978. After two years industry experience in the application of microwave radar to iceberg detection, Mr. Ryan returned to university to complete graduate studies in the application of HF radar to the ice hazard detection problem. In 1983, Mr. Ryan set up and managed the St. John's office of the Calgary firm Viatec Resource Systems Inc. Viatec was active through to 1987 in the investigation of the ability of marine and airborne radar to detect icebergs. In 1987, Mr. Ryan established Sigma Engineering Limited to carry on this work. Since then, Sigma has developed a comprehensive radar performance prediction model and has been involved in the investigation of the ability of airborne radars to detect search and rescue targets.*

ICEBERG DETECTION USING MICROWAVE RADAR

J. Ryan
Sigma Engineering Limited
St. John's
Newfoundland

ABSTRACT

Icebergs represent a potential threat to offshore oil production facilities and shipping. The efficiency and safety of production operations will be affected by iceberg detection capability available to facilities operators.

The presence of icebergs on the Grand Banks of Newfoundland during the spring and summer seasons have long posed problems for shipping and during the past two decades for offshore oil exploration. During ideal daytime weather conditions (i.e.; good visibility) icebergs are easily detected visually and often visual detection exceeds radar detection performance. However, during frequent foggy periods and at night, visual surveillance must be supplemented by radar technology. Radar can penetrate fog, rain and snow and depending on the frequency of operation can achieve over-the-horizon iceberg detection performance. Icebergs, however, are not always detectable on radar due to the poor radar reflective properties of the iceberg and competing radar returns from the ocean (sea clutter). Sea clutter remains the main limitation on the ability of microwave radar to detect icebergs.

The two main types of radar suitable for iceberg detection are microwave radar (3,000 to 10,000 MHz) with basic line-of-sight (to the horizon) operation and HF radar (3 to 30 MHz) which may provide iceberg detection beyond the horizon. Microwave radar studies concerning iceberg detection have been undertaken as early as the 1940s by the United States Coast Guard and more recently the 1980s saw a significant amount of radar research funded by the oil industry and Canadian and Newfoundland governments. This recent work has helped to quantify fundamental radar performance capabilities and to direct research and development programs in radar technology required to increase iceberg detection performance.

This paper will review microwave radar technology as it may be applied to aircraft, ship (support vessel and tankers), and platform configurations. Limitations of existing technology will be discussed and a review of ongoing development work on new radar technology will be provided.

BACKGROUND

A number of factors combine to make iceberg detection using radar one of the more challenging problems in the field of radar. A radar is typically composed of a transmitter and receiver unit both using the same antenna. The radar signal is typically a pulsed electromagnetic or radio wave that is transmitted from the radar unit and reflected by objects back to the radar.

Figure 1 provides an overview of radar geometry. Under normal condition the microwave radar cannot detect targets beyond the radar horizon. As illustrated in Figure 1 a vessel having an antenna at 17 meters height (typical supply boat) will have a radar horizon of about 17 km or 9.2 nautical miles(nmi.). The radar generates a pulse of length τ in a horizontal beamwidth Θ thereby illuminating an area A as shown in Figure 1. The horizontal beamwidth is governed by antenna length and radar operating frequency. The horizontal beamwidth may be decreased by increasing the antenna length or increasing the radar operating frequency.

Objects having high conductivity such as metal ships are very good reflectors of radio waves and therefore make good radar targets. On the other hand, objects with low conductivity such as wooden boats, rubber life rafts and icebergs are all very poor reflectors of radar signals. Shape and surface conditions are also important in determining the strength of signal reflected from a target. The unique nature of icebergs result in a wide range of detection performance even among icebergs of the same above water physical dimensions. The steep faced blocky icebergs tend to give much better reflection than smoother dome shaped icebergs. Table 1 provides the standard iceberg classifications and their size ranges. The size of a target as seen by a radar is referred to as the target radar cross section, σ(sigma), and it has units of area. The radar cross section is useful for comparing different types of targets. Table 2 provides a comparison of radar cross sections of some different ice, ship and search and rescue targets. It may be seen from this table that the iceberg targets have quite small radar cross sections compared to the supply boat. A manned rubber life raft will have a radar cross section comparable to the growler/bergy bit size iceberg. The radar cross section of an iceberg is proportional to its exposed area (above the water line). Research has indicated that the ratio of radar cross section to iceberg area can vary from 0.1 to 0.01, depending on the iceberg shape and condition.

The detection problem is compounded by the necessity of detecting these weak radar targets in a background signal from the ocean itself, sea clutter. The ocean with its salt content may provide stronger radar reflections than the iceberg which is composed of salt-free glacial ice. Reflections from the ocean increase with increasing wind speed and wave height making detection more difficult.

RESEARCH

Research on icebergs has been ongoing for the past 60 or 70 years, having been instigated after the sinking of the Titanic in 1912, predating the development of radar. Subsequent to the loss of the Titanic the International Ice Patrol (IIP) was established to monitor iceberg movement in the North Atlantic in efforts to avoid future accidents. After the second world war research turned to investigations concerning the use of radar for iceberg detection, and the United States Coast Guard and others undertook a number of studies dating from 1945. Williams[1] provides a review of some of the relevant research. This early work helped to identify some of the problems in using radar for iceberg detection, however, not a lot of quantitative data emerged. In the 1970s concern for the safety of oil exploration platforms spurred new interest in the use of radar for ice detection. The microwave radar became a valuable tool for iceberg management. Unfortunately, operational experience indicated that radars did not always perform up to expectation and under certain environmental conditions could not reliably detect the smaller icebergs. Petro-Canada[2] undertook a study in 1980 in the arctic to investigate the potential of existing remote sensing systems to detect and identify ice hazards. The study included marine radar along with infrared and sonar sensors.

With the discovery of Hibernia and other significant oil reserves, the shift towards production systems became of concern and the quest for definitive answers concerning the iceberg detection capability of radar was undertaken. A series of studies, funded from the Environmental Studies Revolving Fund(ESRF) managed by COGLA, were undertaken from 1984 to 1987 to investigate the performance capabilities of marine and airborne radar. These studies had two main objectives. The first was to establish the operational capabilities of specific radars under the available test conditions and the second was to acquire radar data on icebergs and ocean to aid model development. A modelling capability would permit the prediction of radar performance for situations that were not encountered during the field experiments. Research has been undertaken by other groups such as McMaster University and Swedish National Defence Research Institute on the use of radar for ice type discrimination and iceberg detection. The following sections summarize pertinent aspects of this research.

Marine Radar Studies

In the winter of 1984 a field program was undertaken on board the SEDCO 706 semi-submersible drilling platform. During this program digital radar data was collected on icebergs and sea clutter using .

X and S band marine radars (ESRF Report No. 008). This program was extended into 1985 with a ship mounted radar experiment using the M.V. POLAR CIRCLE (ESRF Report No. 035). These two programs saw the collection of data on about 50 icebergs ranging in size from Growler to Large. Viatec Resource Systems Inc. was the contractor on these studies.

The marine radar trials used probably one of the more advanced marine radars available at the time. The unit consisted of a dual X/S band system in which the X band antenna is mounted directly on top of the S band antenna. This mounting configuration permits the synchronization of data from both radars and subsequent combining of their signals at the display.
In 1984 this radar system (Racal-Decca 2459 F/I) was in operational use on the SEDCO 706 semi-submersible drilling platform. The antenna and X and S band transceiver units were mounted on the derrick top at a height of 75 meters. This height gives a radar horizon of about 36 km or 19 nmi. These two radars were instrumented along with separate X and S band units mounted close to deck level. Data was collected on 12 icebergs during April and May. The major findings in this study were:

- The derrick mounted S band radar outperformed all other radars. The poor performance of the deck units was attributed to the lack of recent maintenance and excessively long waveguide runs. The X band derrick mounted radar did not perform as well as expected and its low noise front end was suspected as cause. This was confirmed in tests after the field trials.

- Propagation conditions were identified as having an influence on detection ranges of the larger icebergs. Most of the data obtained during this experiment was for medium icebergs. During enhanced propagation conditions (ducting) medium icebergs were detected in the 17 to 20 nmi range. During normal and foggy conditions detection ranges for medium icebergs were in the range of 14 to 17 nmi.

- ARPA (Automatic Radar Plotting Aid) units do not provide very good performance in clutter limited detection and tracking.
- Ongoing maintenance and performance monitoring should be an integral component of radar operations.

In 1985 another field program was undertaken with the intention of collecting data on smaller icebergs in high sea conditions. The Racal-Decca radar used in the rig-based experiment had been decommissioned and so was available. It was installed on the M.V. POLAR CIRCLE at a height of 15 meters giving a radar horizon of 16 km or 8.6 nmi. A lower power X band ships radar was situated about 5 meters above the installed radar. Data was collected over a one month period on 38 icebergs and numerous other sea ice targets. The major conclusions of this study were:

- S band radar was preferred for operational detection of icebergs in sea clutter although quantitatively there was not a significant difference in measured signal to clutter ratio between X and S bands.

- Very little difference between X and S band for maximum detection range was observed, however, the X band ranges tended to be slightly greater. The X band ships radar mounted at 20 meters height normally had the maximum detection range.

- Detection ranges for small icebergs varied from 5 nmi to 7 nmi with the average detection range of 6 nmi and average size 9 meters high by 40 meters across.

- Detection ranges for medium icebergs varied from 6.4 nmi to 13.3 nmi with an average of 10 nmi. Average iceberg size was 26 meters high and 100 meters across. Detection is, on average, horizon limited.

- Signal processing can significantly improve detectability of smaller iceberg targets is sea clutter.

In an effort to identify possible improvements that could be made to standard marine radars a number of signal processing techniques were investigated. Figure 2 provides an example of the type of processing investigated and presents radar data for a small blocky iceberg in a three meter sea. The iceberg was 7 m high and 48 m wide and had a measured average radar cross section of 15 m². The data is presented in B-scan format where the radar is located on the left and the range from the radar is along the horizontal axis. The top three scans are raw unprocessed data and the bottom scan is the result of processing the radar data over a period of one minute (32 radars scans) by non-coherent integration. The data is quantized in 256 levels (8 bits), however, only 16 are displayed in Figure 2. The iceberg is clearly visible along with the smooth sea clutter background. Note the shadow behind the iceberg (on the right). Figure 3 shows the technique applied to the detection of two moored targets in the Sedco 706 data. An Ordered Statistic (OS) CFAR algorithm has also been applied to this data. The targets were a wave rider buoy at 0.6 nmi and a current meter at 1 nmi and neither target was detectable on the operators display. A supply vessel on close-stand-by duty is also visible. The sea was 1.2 meters with a wind speed of 30 knots . Figure 3 illustrates the benefit of processing only 12 seconds (6 scans) of data.

Search Radar Studies

In 1985 Mobil Oil sponsored a one week experimental study to investigate the suitability of airborne search radar to detect icebergs [3]. The study was qualitative in nature, however, it did demonstrate the potential of search radar to detect icebergs and concluded that search radar would make a useful addition to an iceberg detection and management system.

In 1986 the first operational use of airborne search radar for iceberg surveillance began using a low resolution maritime surveillance radar, APS-504(V)3, and at that time the ESRF funded an evaluation program similar to marine radar studies conducted in 1984 and 1985. The second phase of this program was conducted in 1987 using a more advanced version of the search radar, the APS-504(V)5. During the search radar programs of 1986 and 1987 radar signal data was collected on 27 icebergs ranging in size from Growler to Large. These programs were piggy-backed on operational flights being carried out by Atlantic Airways for Husky/Bow Valley East Coast Project. Sigma Engineering Limited and C-CORE were sub-contractors to Husky/Bow Valley.

APS-504(V)3

The Litton APS-504(V)3 is designed for maritime surveillance with intended applications in ship detection and tracking. It is a conventional non-coherent pulsed radar having a short pulse of 0.5 microseconds and a transmitter peak power of 100 kiloWatts.

In general, it was found that the (V)3 provided very good detection on medium icebergs and good detection on small icebergs in the lower sea states. Detections of bergy bits and growlers were observed, however, this was during very calm conditions. Overall, the radar was found to be very reliable; however, its poor performance on the smaller icebergs in sea clutter limits its usefulness for iceberg surveillance.

APS-504(V)5

The Litton APS-504(V)5 is a more advanced version of the (V)3 and was designed for the detection of much smaller targets such as submarine periscopes. Specifically, it was the objective of the (V)5 design to detect a 1 m² radar cross section in a sea state 3 (1.3 meter significant wave height and 15 knot wind). The radar uses pulse compression to achieve an effective pulse length of 0.03 microseconds and an effective transmitter power of 4000 kiloWatts. The (V)5 also has a longer pulse (0.2 microseconds) for use in maritime surveillance. The radar uses pulse to pulse frequency agility to help in the suppression of sea clutter returns.

Some of the significant findings of the APS-504(V)5 study were:

- The (V)5 provided significantly better performance over the (V)3 with useful levels of detection on bergy bits and small icebergs in the conditions encountered.
- Best overall performance was achieved using the shortest pulse.
- Detection of small icebergs reached 80% over the range of sea states encountered (up to about sea state 5; 3 meter wave height and 23 knot wind) for a line spacing of 20 nmi using the short pulse and looking downwind. Performance was typically better on small icebergs using the longer pulse indicating that if small icebergs are of primary concern the longer pulse may be more appropriate.
- Detection of bergy bits was around 50% at about 10 nmi line spacing, however, this represents data collected over a range of conditions and actual performance for the higher sea states may be less than this.

Overall the search radar was found to provide significant benefits in an operational context. The typical low-altitude searching mode facilitates target verification and identification.

ESRF Airborne Imaging Radar Study

In 1984 the ESRF funded another study to investigate the use of airborne imaging radars to detect icebergs. Data was collected using five airborne radars. Three of the radars were Side-Looking Airborne Radars (SLAR) and two were synthetic aperture radars (SAR). This study coincided with the first continuous use of airborne radar (a SLAR) for operational iceberg surveillance in support of offshore oil exploration on the Grand Banks. SLAR radar technology is similar to marine radar with the main difference being that the SLAR antenna runs along the length of the aircraft and looks to the side of the aircraft. As with marine radar, the area illuminated by the radar increases with increasing range due to the fixed antenna size (or aperture), resulting in poorer resolution in azimuth at longer ranges. SAR generates a long synthetic aperture, the length of which is dependent on the range. This allows SAR to maintain the same azimuthal resolution over its entire range coverage. SAR uses the doppler effect to generate the synthetic aperture and requires much more sophisticated radar hardware and a significant amount of real-time processing of the received radar signal. As SAR depends on doppler processing to achieve its full potential, moving targets can cause smearing on a SAR image, potentially degrading performance. Some SLAR and SAR aircraft have two radar one looking to each side so that coverage area is doubled. The results of this study are provided in ESRF Report No. 016.

Some of the major conclusions from this study were:

- SAR outperformed SLAR for iceberg detection.
- None of the radars consistently detected targets smaller than 10 m^2 area.
- The differences between ships and icebergs were not distinguishable on radar images.
- Iceberg size and shape could not be reliably distinguished from radar images.
- Targets were better imaged in the cross wind (cross wave) direction due to decreased smearing of targets on the SAR imagery.

This study provided a performance comparison among five imaging radars to detect icebergs. The results indicated that SAR could provide a useful role in iceberg surveillance. SAR are typically operated at altitudes of 20,000 feet and provide a swath that is dependent on resolution selected. A typical high resolution swath (desirable for small target detection) would be 20 to 25 km wide. When greater areal coverage is desired a wide swath mode may be used. SAR has been typically used for fixed terrain mapping applications (including concentrated ice cover in the arctic and on the east coast) and as a result processing and presentation has mainly concentrated on producing high quality images. The use of SAR for small target detection in open ocean will require the development of optimal operational and processing procedures for this application. One of the drawbacks of SAR as an operational tactical tool is that it only gets one short look (one to two seconds) at a target as it flies by it. If the target is hidden by waves or is submerged, it will not be detected. In addition, imaging radars are not presently designed to detect and track targets and are therefore not easily used in the detect, track, confirm and locate functions required for tactical operations.

Recent SAR field trails conducted for the Search and Rescue Directorate of the Canadian Coast Guard by Nordco Limited and Sigma Engineering Limited demonstrated that SAR could be operated effectively at lower altitudes (3000 feet) and that small life raft targets could be detected. Some of this data will be reprocessed to investigate alternate processing schemes to improve performance. This work is presently in the final data analysis stage and results will be applicable to the iceberg detection problem.

Coherent Radar

Since the early 1980's the Communications Research Laboratory(CRL) of McMaster University has been involved in experimental work investigating the ability of radar to discriminate ice types. A significant amount of their research was conducted in the Arctic where it is desirable, for navigation purposes, to discern the difference between the older, harder multi-year ice, icebergs and the softer first-year ice. Through a series of experiments CRL selected a set of desirable parameters for an instrumentation-quality research radar. This radar, named IPIX (Ice multiParameter Imaging X band), was first used for experimental data collection in 1988 at Cape Bonavista, Newfoundland. The IPIX radar has a number of features presently not available in standard marine radar. The two significant features are:

- Dual Polarization. Benefits in ice discrimination.
- Coherent. Permits analysis or processing of data from a doppler spectrum point of view. This feature shows the most promise in the application of iceberg detection.

The coherent doppler processing capability of the IPIX radar is very similar to the prototype operational radar developed by the Swedish National Defence Research Institute, ICERAD, and reported in 1987 [4]. ICERAD was abandoned due to a lack of civilian funding and a shift of emphasis to other targets of military interest. Very little quantitative data is available on the performance of ICERAD in the detection of icebergs.

McMaster has conducted shore-based tests at Cape Bonavista and has demonstrated successful detection of iceberg targets in moderate sea conditions. Figure 4 from Currie[5] shows data collected on a growler (designation used in paper) using IPIX at Cape Bonavista. The target dimensions were estimated from photographs to be 2 m high by 10 m wide. The data was all taken from one radar resolution cell (approximately 30 m by 250 m) over a period of 34.5 seconds. Doppler spectra are computed every half second (512 point Fast Fourier Transform). The iceberg is clearly visible as the wiggly dark line caused by changing iceberg velocity as it is moved by wave action. The wave height is reported to be 1.6 m with a peak period of 11 seconds.

Model Development

The individual marine and search radar experiments conducted from 1984 to 1987 provided operational detection results, however, a significant amount of digital radar data collected was not analyzed. This data base has since been archived at the facilities of the Canada/Newfoundland Offshore Petroleum

Board. In 1988 a major development project was undertaken to analyze this data and to incorporate the results into a radar performance prediction model. The objective was to develop a computer model that could be used to assess the ability of candidate radars to detect icebergs and other small targets. The model could be used to select appropriate radars for use in offshore exploration and production and shipping, designing operational procedures and in risk analysis studies. This project was supported by a grant to Sigma Engineering Limited from the Research and Development Program, Canada/Newfoundland Offshore Development Fund.

The data was analyzed to extract iceberg radar cross sections for X and S band radars. This information was used to derive statistical properties of iceberg radar cross section both as a function of iceberg size and time. Figure 5 for S band shows one form in which these results may be presented and used. The Figure presents the ratio of radar cross section (σ; RCS) to iceberg physical area (projected in the direction of the radar) in terms of percentage exceedance. The Figure indicates, for all the targets measured in the size class from growler to small iceberg, that for 90% of the targets the ratio of RCS to projected area was greater than 0.01 m^2/m^2, and all targets had a ratio greater than 0.005 m^2/m^2. A bergy bit having a projected area of 20 m^2 would result in a radar cross section of 0.2 m^2 (20 m^2 times 0.01 m^2/m^2) at the 90% level. A growler size piece glacial ice having a projected area of 1 m^2 would have a cross section of 0.01 m^2 at the 90% level. This is 100 times smaller than the radar cross section of a steel sphere of the same projected area (see Table 2). Similar data is available for X band [6].

This data may be used to estimate the radar cross section of the iceberg target of interest and place limits on the maximum and minimum cross section expected. In addition to this type of statistical data empirical relationships have been derived from the data relating iceberg radar cross section to physical area.

Sea clutter data from the four field trials were analyzed and average and higher order statistical moments calculated. The average normalized radar cross section of the sea clutter, $\sigma°$, was calculated as a function of environmental conditions and compared to published models. These models included the Georgia Institute of Technology model [7] and the H. Sittrop model [8]. The data has been compared to these models for $\sigma°$ using the Chi-squared goodness of fit test. These comparisons have shown that the Georgia Tech model provides good predictions for the average radar cross section of sea clutter [9]. The Sittrop model also works well, however, it is only applicable to X and Ku bands.

The statistical properties of sea clutter are complex and will vary with radar parameters and environmental conditions [10]. Models for the statistical properties of sea clutter vary from the Rayleigh distribution for low resolution radars and high grazing angles to Weibull and Lognormal for high resolution radars and/or low grazing angles [11].

The K-distribution has been proposed as an alternative model for sea clutter [12]. In the K-distribution model, the envelope of the amplitude of the clutter returns consists of two components, permitting the modelling of clutter having components with different correlation times. The first is the local mean clutter level, described by a Chi distribution. The second component, termed the clutter speckle, is Rayleigh distributed with a mean determined by the first component. As the correlation of each component can be identified simply, the compound distribution enables both amplitude and correlation effects to be taken into account.

Using the moments of the data to compute the parameters of the potential fluctuation models, it has been found that the K- distribution is the most appropriate model.

A radar performance prediction model has been implemented in software. The model makes use of iceberg radar cross section data derived from a large experimental data base collected on the Grand Banks of Newfoundland. The model uses a validated sea clutter model to estimate the effect of sea state on average sea clutter. The compound form of the K-distribution is used to model sea clutter statistics. The use of the K-distribution permits the modelling of detection performance of radars from standard low resolution marine radar to high resolution pulse compression radars such as the Litton APS-504(V)5. The model is valid for use at both X and S bands and the formulation provides for the assessment of various non-coherent processing techniques for both fixed frequency and frequency agile radars. Figure 6 provides example performance for the detection of a Bergy Bit in sea state 5 using an derrick mounted S band radar. Figure 6 also shows expected performance when scan to scan processing is used with a standard marine radar and with a radar capable of frequency agile.

CONCLUSIONS

A significant amount of research has been undertaken on the use of radar for iceberg detection. This research has identified the fundamental capabilities of existing radar and provided important measurements on the radar characteristics of icebergs and ocean. This knowledge has been used to develop a comprehensive radar performance prediction model that may be used to evaluate candidate radars and signal processing hardware for offshore platform and tanker applications.

The research also indicates that there are substantial improvements in performance that can be achieved using standard marine radar technology supplemented with non-coherent processing techniques. These processing schemes have been proven to work on iceberg signals. While real-time versions of this technology are relatively easily implemented with today's computer technology the radar industry has been slow to react. This is likely due to the perceived small size of the iceberg detection market. Increased concern over the ability of standard marine radar to detect search and rescue targets and other small targets at sea may help expand the market potential for enhanced marine radars. New radar technology such as the CRL/Litton IPIX radar show promise for use in iceberg detection, however, it is expected that these systems will be substantially more expensive than an enhanced standard marine radar. In order to ensure availability of either technology it is important for potential end-users to indicate their commitment to use it.

Airborne and eventually spaceborne radars (for example RADARSAT) will probably remain mainly as strategic support sensors providing information on the movement of icebergs into the area of interest and updates of the overall iceberg distribution. Tactical use of airborne radars would require substantial airtime to provide continuous real-time data necessary for ongoing operations. A potential airborne application that may prove useful would be helicopter mounted search radar based on the GBS or tankers and used as deemed necessary. The main problem with this approach would probably be related to restricted operations in bad weather. Search radar has been accepted as a useful radar for the iceberg surveillance application, however, Synthetic Aperture Radar (SAR) also shows potential with target identification remaining one of its drawbacks.

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All reports ESRF reports referenced in this paper are available at the library of the Canada/Newfoundland Offshore Petroleum Board in St. John's.

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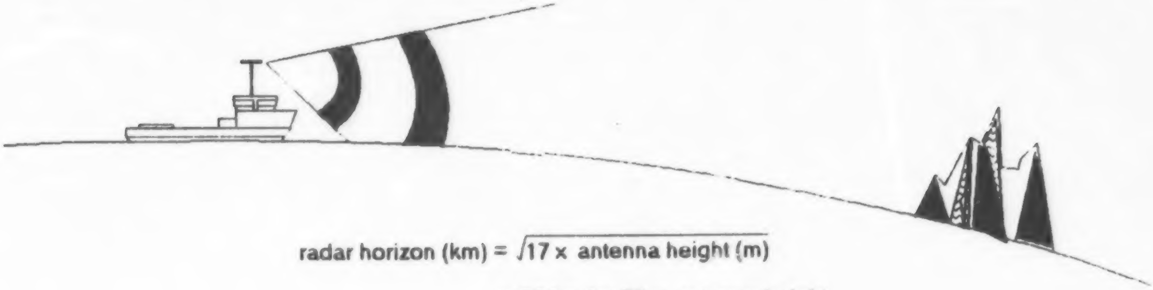
TABLE 1 ICEBERG SIZE CLASSIFICATION

SIZE	HEIGHT (m)		LENGTH (m)	
	Tabular	Other	Tabular	Other
Growler		<1		<6
Bergy bit		1-5		6-20
Small	<6	5-15	<90	20-60
Medium	6-15	15-45	90-120	60-120
Large	>15	45-75	>120	20-210
Very large		>75		>210

TABLE 2 TYPICAL TARGET RADAR CROSS SECTIONS (RCS)

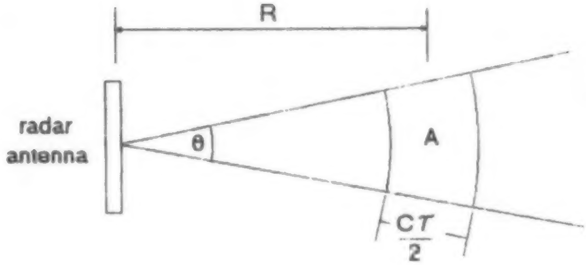
Target	RCS (m^2)	Projected Area (m^2)
Growler	0.01-0.1	2
Bergy bit	0.5 -1.0	60
Small iceberg	5-10	400
Supply vessel	150	400
Liferaft(4 man)	0.25-0.5	3
Steel sphere (1.13 m dia.)	1	1



radar horizon (km) = $\sqrt{17 \times \text{antenna height (m)}}$

= 36 km for 75 m antenna height

= 17 km for 17 m antenna height



$A = \frac{C\tau}{2} \times R\theta$; resolution cell area

θ = horizontal beamwidth , radians

τ = radar pulse length , seconds

C = speed of light , 3×10^{8} m/s

R = range , m

Figure 1 Radar Geometry

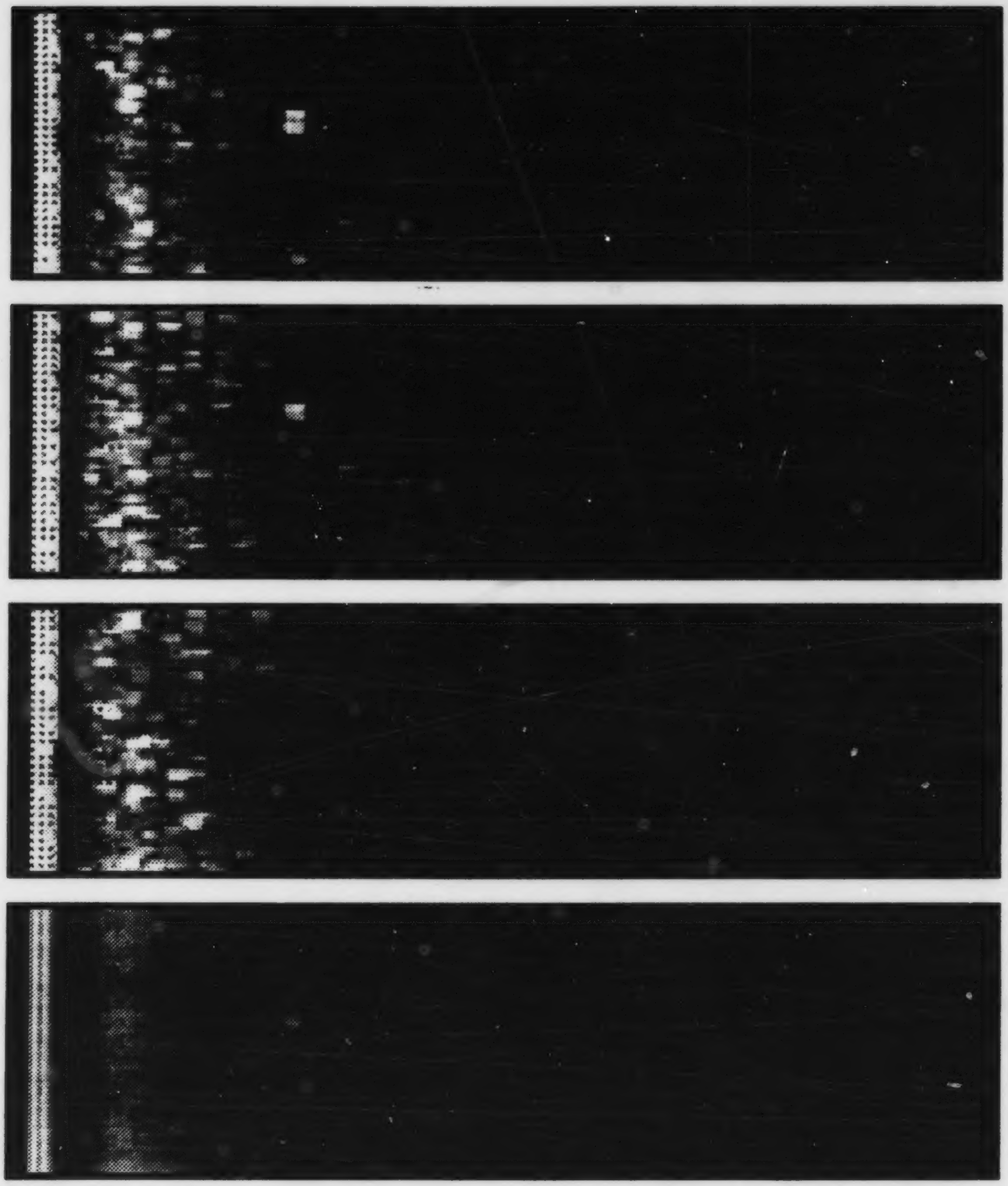


Figure 2 Small Blocky Iceberg in Sea Clutter. Wave height was 3 meters and wind speed 19 knots.

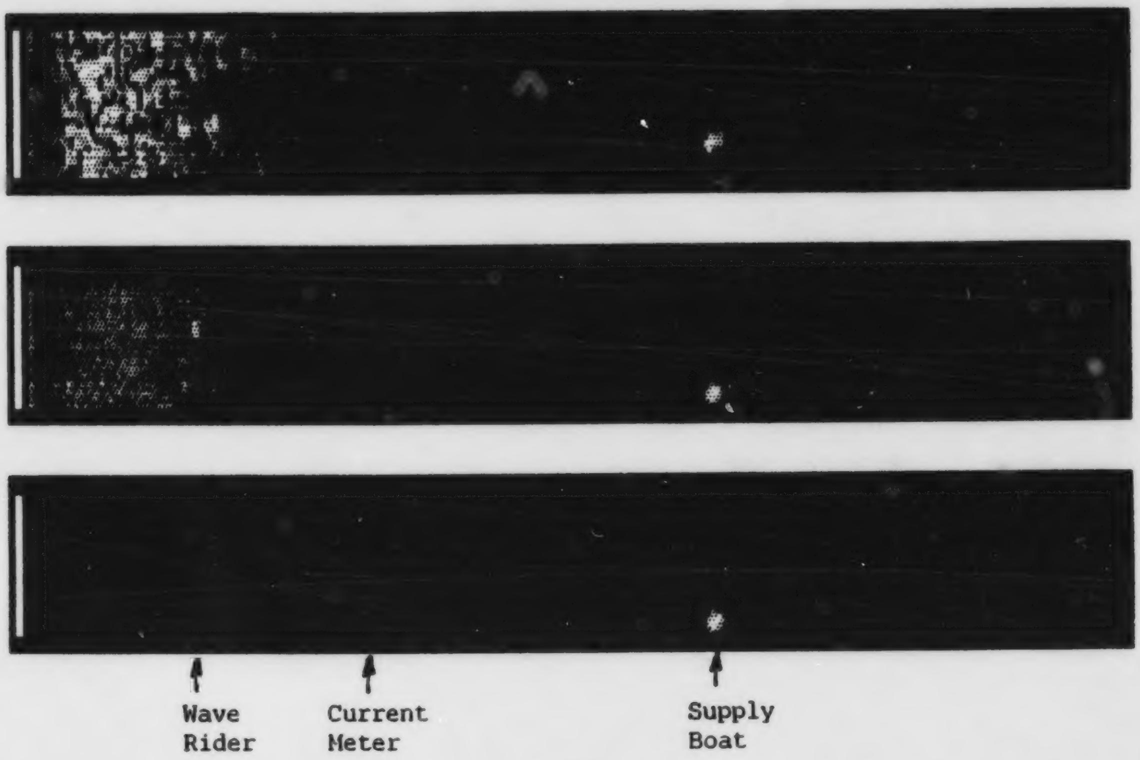


Figure 3 Radar Data for a Wave Rider Buoy, Current Meter and Supply Vessel in 1.2 meter sea and 30 knot wind. Top scan: raw data; Middle scan: integration of six scans; Bottom scan: Ordered Statistic CFAR and integration of 6 scans.

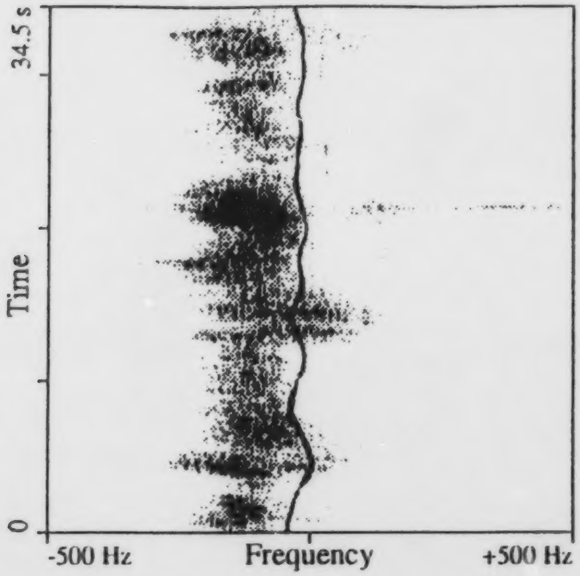


Figure 4 Doppler Frequency Spectra versus time for a Growler and Sea Clutter using IPIX radar [5]. Wave height was 1.6 meters.

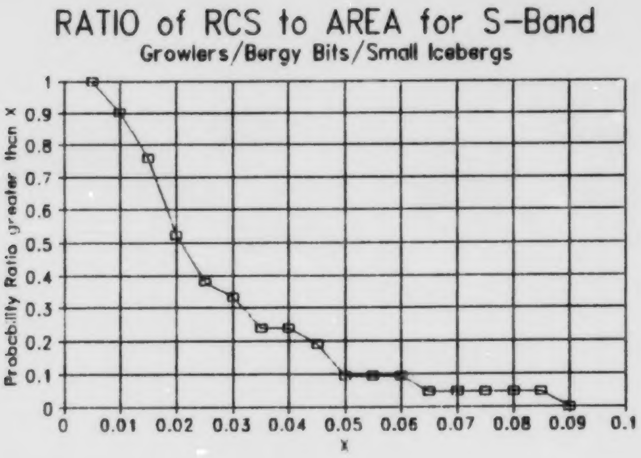


Figure 5 Ratio of Iceberg Radar Cross Section to Physical Area Projected Towards the Radar.

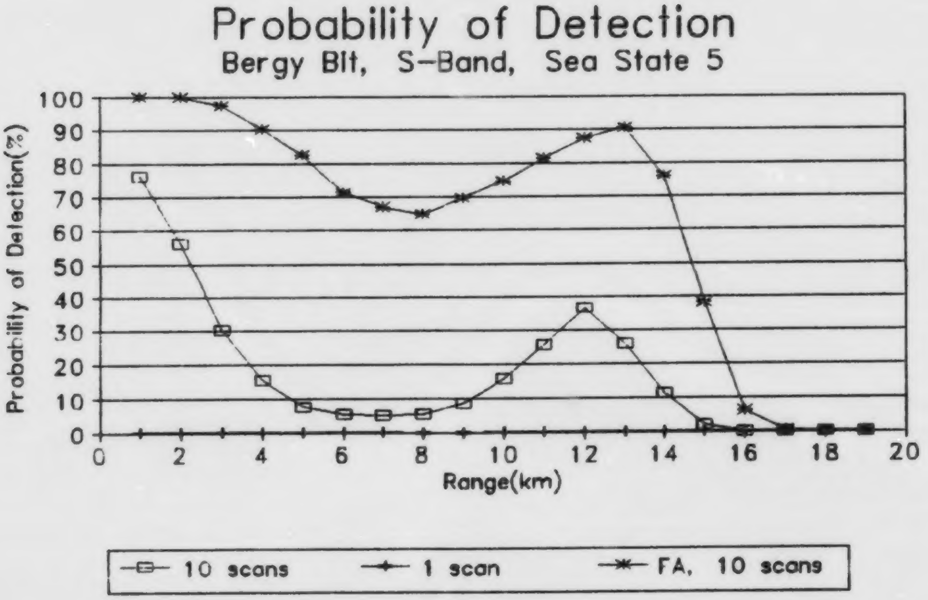


Figure 6 Probability of Detection for a Bergy Bit using a Derrick Mounted S band Radar in Sea State 5. Curves for a standard marine radar (1 scan); standard marine radar with scan to scan integration of 10 scans (10 scans); Frequency Agile radar with 10 scans integrated (FA, 10 scans). 0.05μs pulse. K-dist. shape parameter = 0.3

SPEAKER : ***DR. A.M. PONSFORD***

COMPANY : ***NORDCO LIMITED***

LOCATION: ***ST. JOHN'S, NEWFOUNDLAND***

TOPIC : ***LONG RANGE DETECTION OF ICEBERGS AND SHIPS USING GROUNDWAVE RADAR***

BIOGRAPHY: *Tony Ponsford received the B.Sc. Degree in Maritime Technology from the University of Wales, in 1983. From 1983 to 1987 he was employed by the University of Birmingham as a Research Associate specializing in ground wave radar and received a Ph.D degree in Digital Beamforming for ground wave radar in 1990. Since 1988 he has been employed by Nordco Limited of St. John's Newfoundland as a Senior Communications specialist and Manager of the HF Radar Programme.*

LONG RANGE DETECTION OF ICEBERGS, SHIPS AND AIRCRAFT USING GROUND WAVE RADAR

A.M. PONSFORD* and S.K. SRIVASTAVA#

*NORDCO Limited, St. John's.

#Formerly with NORDCO Limited now with Calian Technology Limited, Ottawa.

ABSTRACT

During the past five years NORDCO Limited has been developing a ground wave radar facility on the east coast of Newfoundland at Cape Bonavista. The radar has been used to demonstrate ground wave radar technology to both government agencies and industry. These demonstrations have included the long range detection of aircraft, ships and icebergs as well as the remote sensing of ocean surface currents and surface winds.

In the initial experiments, a former LORAN-A navigation beacon was modified for use as the radar transmitter. Following the successful demonstration of the radar's long range detection capabilities, the radar has been developed to a stage suitable for commercial marketing and uses the latest "state-of-the-art technology" in both transmitter and receiver design as well as advanced signal processing techniques.

During the past five years NORDCO has also been developing a generalized software simulation model for both predicting and optimizing the performance of ground wave radars. The simulation includes models of the hardware, the environment and the target cross section.

The paper summarizes results of comparisons between the measured radar performance and that predicted using the simulation software. Typical detection ranges are presented for a variety of targets.

Radars operating on the east coast of Canada will be affected by sea ice coverage. A summary of the theoretical added loss experienced by the radar wave when propagated over coastal sea ice is included in this paper as well as a general discussion on radar operating frequencies.

KEY WORDS: Long Range Radar, Ocean Surveillance.

INTRODUCTION

The long range detection and tracking of surface vessels using ground wave radar was initially reported by Kumar and Bagwell (1983) and by Ponsford et al. (1984). The 1984 report presented the results of a number of tracking exercises including one in which a 50,000 ton vessel was tracked to well beyond 200 km. This stimulated considerable interest in ground wave radar for long range target detection. Since then significant progress in the application of ground wave radar technology, for the tracking of ship targets, has been made, for example Ponsford et al. (1987) and Cuff et al. (1990). The results presented by Cuff were obtained using NORDCO's ground wave radar facility at Cape Bonavista during trials with the Canadian Navy. The data obtained from these trials have been extensively compared with NORDCO's simulation software model predictions and are reported in detail by Ponsford and Srivastava (1991a).

The detection of icebergs using ground wave radar was initially reported by Walsh et al. (1986). These detections were obtained using a CODAR radar system operating at 25 MHz and hence were limited to relatively short ranges (< 30 km). In the spring of 1990, NORDCO Limited demonstrated the detection and tracking of icebergs to ranges in excess of 280 km using their ground wave radar at Cape Bonavista. The results have been compared with model predictions and will be presented in detail by Srivastava and Ponsford (1991)

This paper summarizes the above results and draws conclusions regarding the operation of ground wave radars in the role of territorial surveillance on the east coast of Canada. A detailed description of the radar site, experimental results and simulation software are given by Ponsford and Srivastava (1991b)

THE RADAR SITE

The Cape Bonavista radar operates throughout the HF band (2 MHz to 30 MHz) and has a maximum operational range of 500 km. The transmitter consists of paralleled broadband, solid state, RF power amplifiers that have been optimized for pulse mode operation. The transmitter feeds into one of two transmit antennas, dependent upon frequency and application. The transmitter can be controlled remotely via a modem. The receive site is approximately 1 km distant from the transmitter and encompasses two linear arrays. A low band array covers the frequency range 2 to 5 MHz and a high band array covers the frequency range 6 to 30 MHz. The individual array elements feed either, directly into a high dynamic range frequency translator unit, or via an antenna multiplexing unit. The antenna multiplexing unit switches a maximum of eight antenna elements to a single frequency translator unit and is used to reduce costs in situations where a slight degradation in radar performance is of no significance. This includes applications such as long range ocean surveillance and ocean surface current monitoring.

The output from the frequency translator units are digitized to 16 bit precision at sampling frequencies of either 125 kHz, 250 kHz or 500 kHz by a NORDCO designed analog-to-digital converter (ADC) unit. Each individual unit is capable of interfacing to eight translator units and may be paralleled to accommodate more.

The outputs from the ADC unit are processed in the first instance by a NORDCO developed pre-processing unit which performs the functions of bandpass filtering, frequency shifting to base band, and forming the inphase and quadrature signal components. The units are under the control of a master control program which selects the appropriate filter responses and mixing frequencies. The units process data in real time and output the complex base band signals to a Versa Module European (VME) based signal processing unit.

The signal processing unit performs the tasks of Doppler processing the time accumulated range samples and digital beam synthesis. An interpolation beam synthesis technique developed by Ponsford (1990) is used to refine the azimuth of a target to within approximately 10 per cent of the receive array beamwidth and a similar technique is used to refine the range of a target. The unit outputs; range, radial velocity, azimuth, and signal strength of the target to a display screen developed by Ultimateast Limited of St John's.

SOFTWARE MODEL

An advanced ground wave radar performance simulation software has been developed by NORDCO for both predicting and optimizing the performance of ground wave radars under differing tasks and environmental conditions. The main components of the model consist of modules that provide estimates of transmission loss, sea clutter and external noise level. This information is used for predicting the detection of any given target of known radar cross section. The target cross section is modelled separately. The output of the model is in the form of the received power spectrum levels of target, sea clutter and noise. A summary of the software model has been previously presented elsewhere (Ponsford et al., 1989; Srivastava and Ponsford, 1989).

The simulation software is presently being expanded to permit modelling of bi-static radar operation, and radar operation from a moving platform.

TARGET CROSS SECTION MODELS

Target cross section models have been developed, in software, for predicting the radar cross section of both icebergs and man made targets situated on and above the ocean surface.

Iceberg Cross Section Model

The iceberg cross section model has been previously presented by Ponsford et al. (1989) and Srivastava and Ponsford (1991). It is shown in these papers that, within the HF band, the radar cross section of icebergs (waterline contour area greater than 400 square meters) is virtually independent of radar carrier frequency and directly proportional to the waterline contour area of the iceberg. That is:

$$\text{X-section} = 0.06 \times \text{contour area} \tag{1}$$

Man Made Target Cross Section Model

Man made targets are modelled in the first instance as a perfectly conducting parallelepiped located on or above the earth's surface. The software model is based on the theoretical model proposed by Walsh et al. (1986) and is described in detail by Ponsford and Srivastava (1991a and b). It is shown that, provided the dimensions of the target are at least comparable to the carrier wavelength then, except for resonance effects, the radar cross section is again virtually independent of radar carrier frequency.

COMPARISON BETWEEN MODELLED AND OBSERVED RADAR DATA.

Iceberg

An example of the observed radar response of an iceberg obtained using the Bonavista radar operating at 1.95 MHz is shown in Figure 1. The iceberg is at a range of 282 km from the radar and lies along the line of boresight. The physical size of the iceberg was measured at the time of the radar observation to be 151 meters in length, by 56 meters in breadth and 30 meters in height. From (1) the theoretical radar cross section is 27 dB sq.m.

The result of running the simulation software model for comparison with the above detection is presented in Figure 2. Ground truthing of the ocean was obtained using a directional waverider buoy. The excellent agreement between the measured and predicted responses is apparent in the illustration.

Vessel

An example of the observed radar response of a vessel obtained using the Bonavista radar operating at 1.95 MHz is shown in Figure 3. The vessel is the Canadian Fleet Auxiliary Vessel "Bluethroat" which was at a range of 140 km from the radar and approximately broadside on to the radar. The "Bluethroat" measures 47 meters in length, by 10 meters in breadth, with approximately 3.5 meters of hull above the waterline. The estimated radar cross section is 59 dB sq.m.

The result of running the simulation software model for comparison with the above detection is presented in Figure 4. Ground truthing of the ocean was again obtained using a directional waverider buoy. As for the iceberg target excellent agreement exists between the measured and predicted responses.

Aircraft

The observed radar response of an aircraft obtained using the Bonavista radar operating at 1.95 MHz is demonstrated in Figure 5. The aircraft is a four engine turboprop that measures approximately 36 meters in length with a wing span of 30 meters. It is at a range of 56 km from the radar. The slight spread in the aircraft Doppler return is associated with a change in radial velocity due to a turning manoeuver. The estimated radar cross section of the aircraft is 24 dB sq.m.

The result of running the simulation software model for comparison with the above detection is presented in Figure 6. Ground truthing of the ocean was again obtained using a directional waverider buoy. Once again excellent agreement between the measured and predicted responses is observed.

Typical detection ranges achieved using the Bonavista radar are presented in Table 1.

CHOICE OF RADAR OPERATING FREQUENCY

The above detections illustrate the potential of ground wave radar and also the degree of confidence that can be placed in the simulation software model. Using this simulation software optimum frequency bands, for a given radar configuration, environmental conditions and target detection scenarios, can be determined.

For example, it is well known that the propagation loss of ground waves over a smooth sea increases with frequency as does the added loss due to surface roughness. Surface targets are usually detected against the contending second order clutter continuum. For a given radar cell area (defined by the receive antenna pattern beamwidth and transmitted bandwidth) the second order continuum level increases with radar frequency. However the continuum level can be reduced by reducing the radar cell area. Narrow beam antennas are generally more available at the higher frequencies. For example, a 10 degree beamwidth requires an aperture of 750 meters at 2 MHz or 50 meters at 30 MHz. Against this is the requirement for continuous, contiguous ocean surveillance and the narrower the antenna beam the greater the number of beams required to cover a given area, and hence the greater the system complexity and cost.

In general, when the target dimensions are at least comparable to the radar carrier frequency the radar cross section of a target is virtually independent of carrier frequency. However, for targets whose dimensions are considerably less than the radar wavelength, the cross section drops off rapidly. Small target detection can therefore be improved by operating the radar at a higher frequency.

A well designed radar system will be externally noise limited. The external noise level at a rural site such as Bonavista will be dominated by man-made noise and is thus virtually independent of the time of day and season. This has been shown to be the case at Cape Bonavista with the external noise level decreasing with increasing frequency as is expected. The measured noise levels are in excellent agreement with the modelled noise data.

The operation of ground wave radars on the east coast of Newfoundland requires that the effect of coastal sea ice coverage be taken into account. This has been modelled using the approach of Wait (1962) and Hill and Wait (1981) and has been included in the simulation software as an added loss to the basic transmission loss used in the radar range equation. For example, Figure 7 plots the added loss at 2 MHz for four typical ice thicknesses of 0.5, 1.0, 1.5, and 2.0 meters. It may be observed that the added loss is minimal and virtually independent of ice thickness. The loss increases significantly with frequency as can be observed from Figure 8 which depicts the added loss at 10 MHz for the same ice thicknesses.

To summarize the above, in general for long range radar operation (> 200 km) it is more cost effective to use a frequency at the lower end of the HF band (2 MHz to 6 MHz). However, at near ranges, operating at the higher end of the HF band has advantages in terms of small target detection and accuracy in both azimuth and velocity measurements. Also, the availability of free channels increases at the higher frequencies and thus the probability of being able to operate with a larger transmitter bandwidth increases and hence offers improved range resolution.

CONCLUSIONS

This paper has summarized some of the results obtained to date from the Bonavista ground wave radar. It has been shown that long range detection of targets can be achieved by operating at the lower end of the HF band. The results obtained are in excellent agreement with the predicted results from the simulation software which is presently being used to design optimum radar configurations.

ACKNOWLEDGEMENTS

The Cape Bonavista radar station has been developed by NORDCO Limited under contract from the Canadian Department of National Defence. The transmitter site is on loan from the Canadian Coast Guard. The simulation software was developed by NORDCO Limited under contract from both the Canada-Newfoundland Offshore Development Fund and the Department of National Defence. We gratefully acknowledge the financial support and encouragement received for conducting these detection trails from the Department of National Defence, The Atlantic Accord Offshore Development Fund, and the Hibernia Management and Development Company all of who funded the iceberg detection trials.

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TABLE 1

DETECTION RANGE FOR

BONAVISTA RADAR 1, AUGUST 1989

SHIPS		RCS dB sq.m	DETECTION RANGE
SMALL	(500 grt)	40	250 km
MEDIUM	(10,000 grt)	60	400 km
LARGE	(100,000 grt)	70	>500 km

AIRCRAFT		RCS dB sq.m	DETECTION RANGE
MEDIUM	(Length 35 m)	25	150 km

ICEBERG		RCS dB sq.m	DETECTION RANGE
SMALL	(10^3 sq.m)	20	200 km
MEDIUM	(10^4 sq.m)	27	400 km
LARGE	($>10^4$ sq.m)	35	>500 km

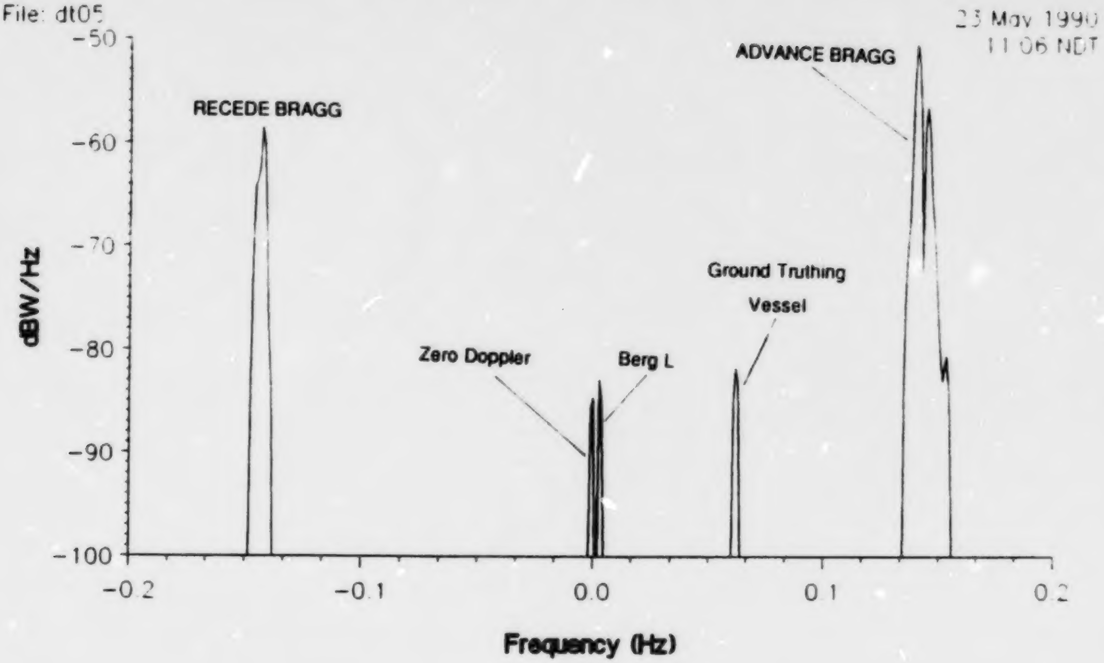


FIGURE 1 Radar Derived Data From Iceberg L Detection: Range 282 km, Boresight Beam. Note: Return from ground truthing vessel is also visible.

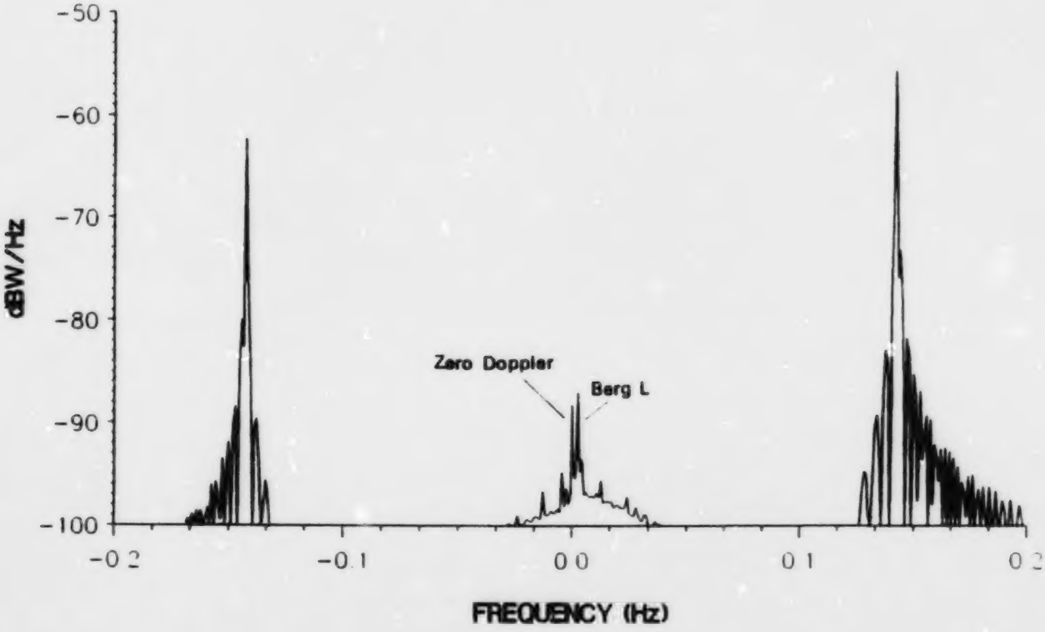


FIGURE 2 Simulated Data For Iceberg L Detection at 282 km.

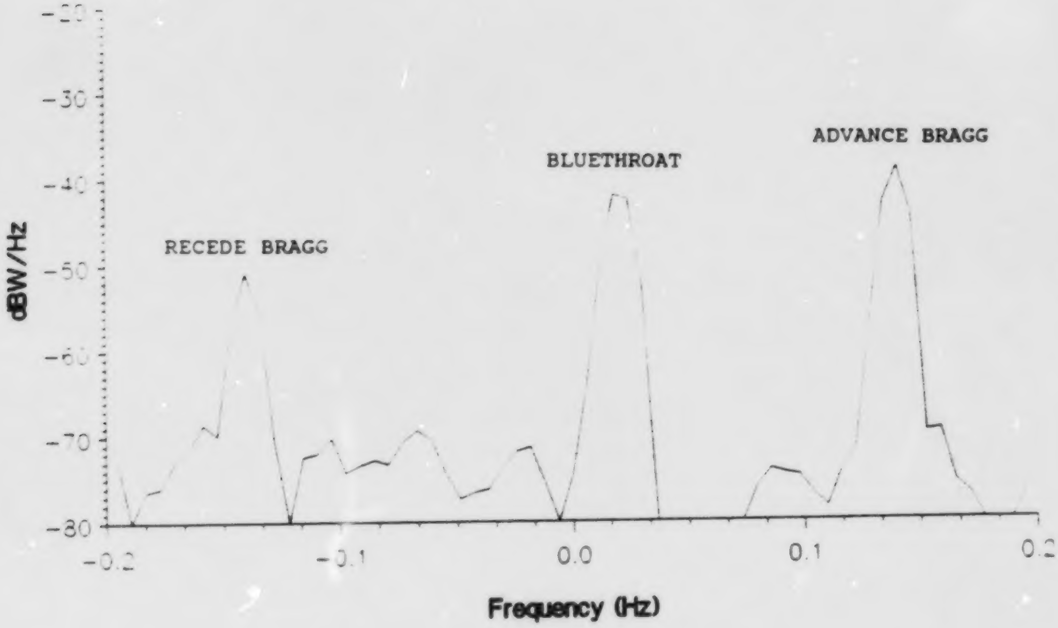


FIGURE 3 Radar Derived Data From CFAV Bluethroat Detection Exercise: Range 145 km, Boresight Beam.

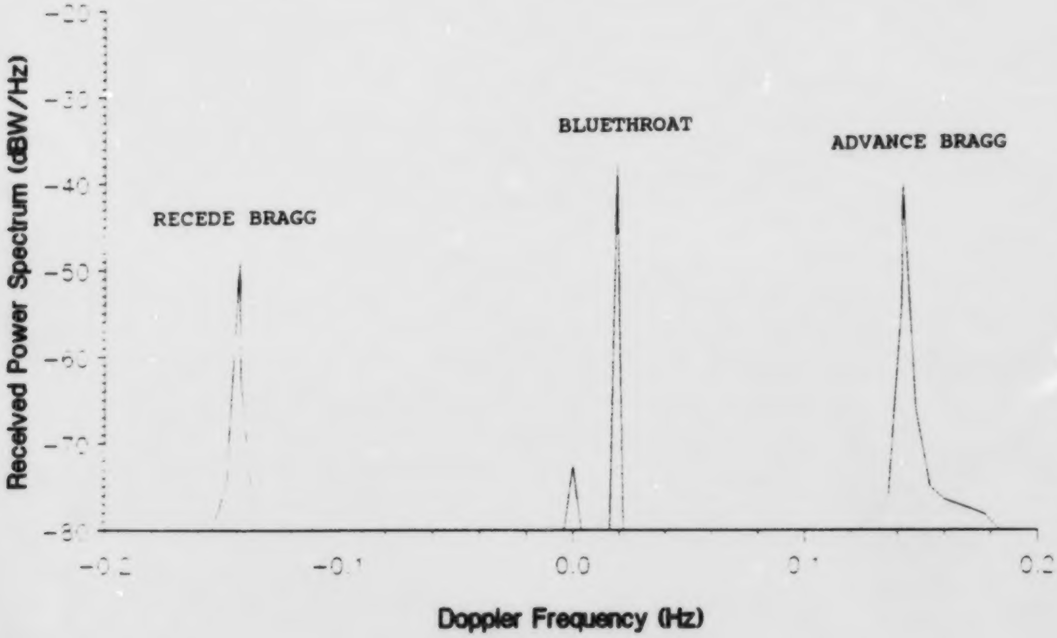


FIGURE 4 Simulated Data For CFAV Bluethroat Detection at 145 km.

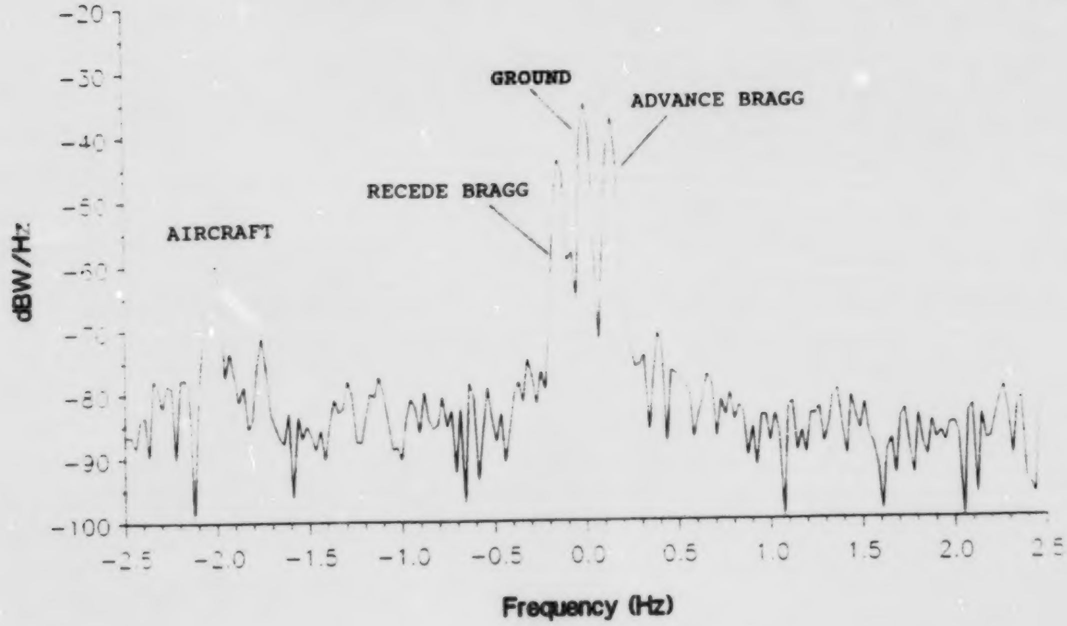


FIGURE 5 Radar Derived Data From Aircraft Detection Exercise: Range 56 km, Boresight Beam.

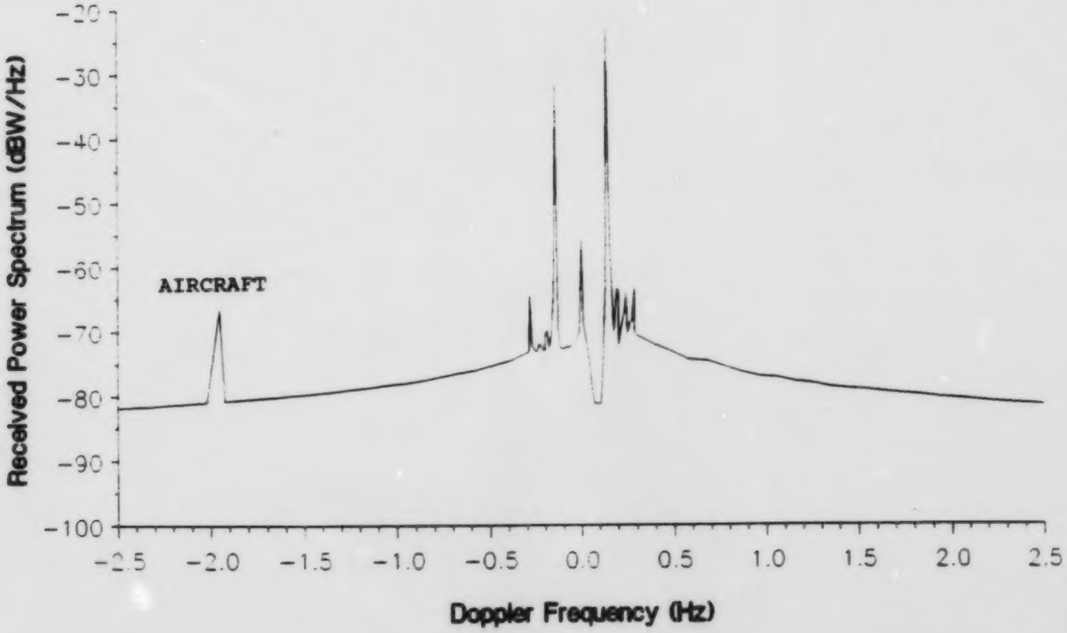


FIGURE 6 Simulated Data For Aircraft Detection at 56 km.

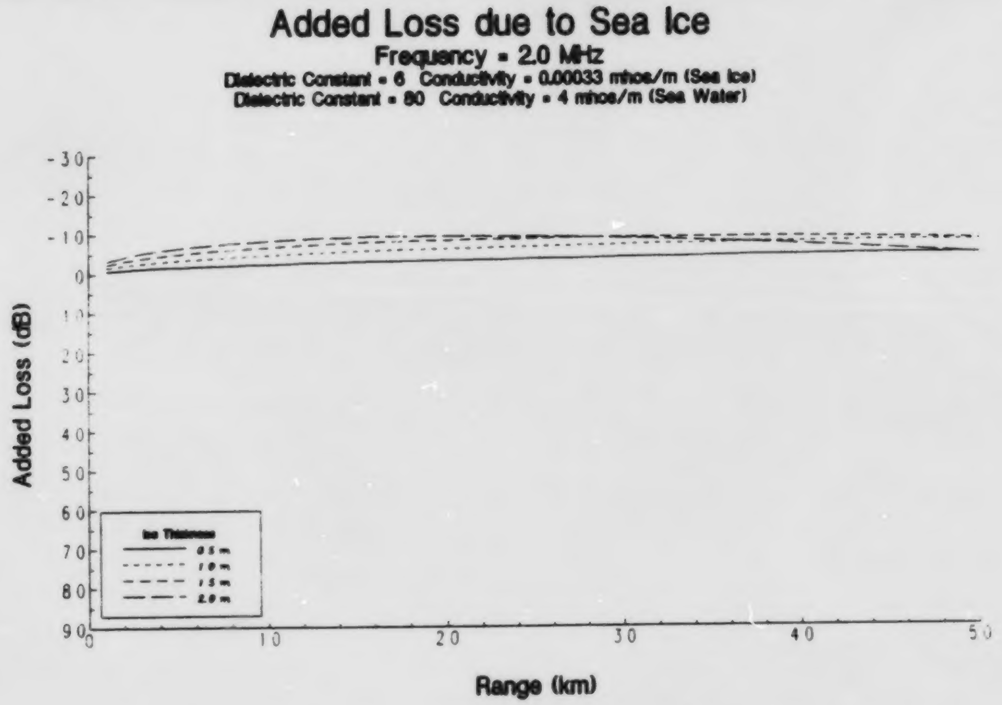


FIGURE 7 Added Propagation Loss Due to Sea Ice Coverage at 2 MHz For Ice Thicknesses 0.5, 1, 1.5, 2 meters.

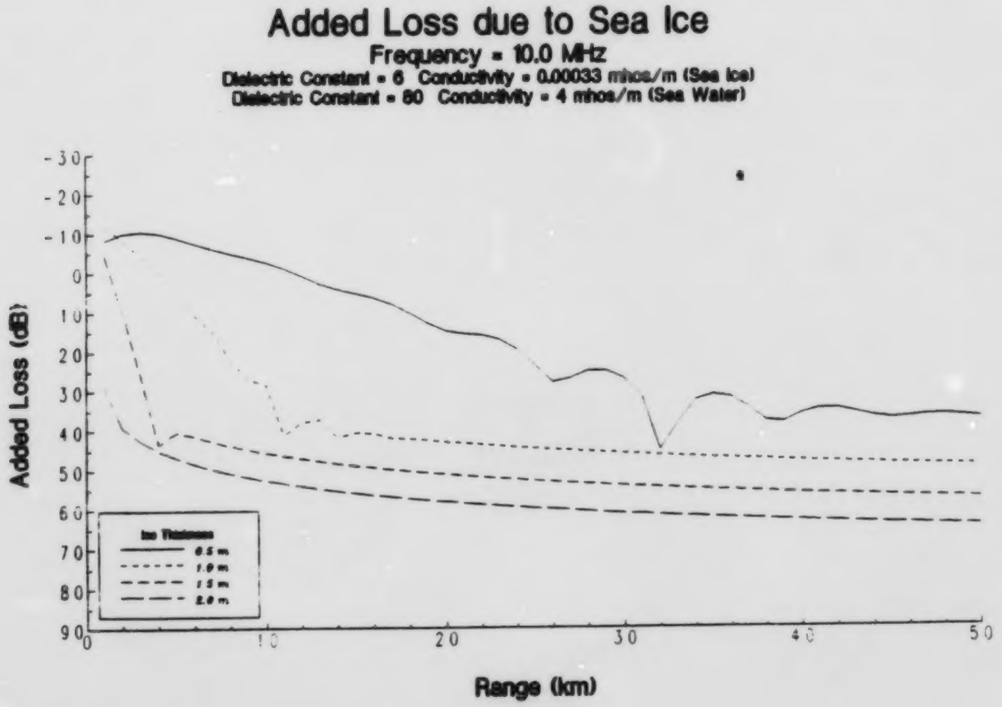


FIGURE 8 Added Propagation Loss Due to Sea Ice Coverage at 10 MHz For Ice Thicknesses 0.5, 1, 1.5, 2 meters..

SPEAKER : ***DEREK LANGFORD***

COMPANY : ***NEWFOUNDLAND OFFSHORE CONTRACTORS - NOC***

LOCATION: ***MONTREAL, QUEBEC***

TOPIC : ***3D CAD DESIGN ASPECTS OF THE TOPSIDES UNIT FOR THE HIBERNIA PLATFORM***

BIOGRAPHY: *Derek Langford is the Engineering Manager for Newfoundland Offshore Contractors and is responsible for direction of all engineering work on the Hibernia Topside Facility. The design will make extensive use of CAD in the design process. Mr. Langford has been employed for the past 15 years by Brown & Root, working primarily in London, England. He has been responsible as engineering manager on several major North Sea production platforms which have been fully detail designed using 3D CAD. Mr. Langford has an Honours Degree in Mechanical Engineering from the University of Surrey, England and is a fellow of the Institution of Mechanical Engineers.*

Derek has been assisted in the preparation of his paper by Duncan Pearce who is the Technical Systems Manager for Newfoundland Offshore Contractors. He brings CAD expertise from the North Sea to the Hibernia Project. Duncan has a Degree in Applied Science (mechanical engineering, major) from the University of Sussex and is a Graduate of the Institution of Mechanical Engineers.

1. Introduction

Computer systems are utilized on the Hibernia topsides for engineering analysis, 2D drafting, a variety of Engineering and project management data bases and full three dimensional design and drafting. In this paper I would like to present the methods by which the 3D CAD portion of the Engineering Design work is being managed. 3D CAD design modelling is a complex application and its use fundamentally dictates the way the design phase of the project must be executed.

The working procedures implemented on the Hibernia project are based on similar ones developed both in the U.K. and Norway during the past five years, incorporating lessons learnt and adaptation to suit the software and hardware configuration adopted on the project. My paper will concentrate on these working sequences including the principles used for progress monitoring and close by giving a brief summary of the hardware configuration.

I will set the scene by giving you an overview of the project which was described yesterday in some detail by Dick Rolstad, the Project Manager of Newfoundland Offshore Contractors.

2. Project Description

The topsides of Hibernia project consists of five super modules which will be fabricated both in Canada and Internationally. These will be assembled at the Bull Arm site here in Newfoundland to form an integrated deck. The topsides have a dry weight of 35,000 tonnes during mating with the GBS and have an operating weight of 60,000 tonnes.

The primary scope of NOC work is for detailed design and procurement of the topsides facilities. Some 20,000 Engineering Drawings are currently planned with all key construction documents produced by CAD. Design work takes place both in Montreal and St. John's, Newfoundland. The project is currently in the early stages of detail design.

The main components of the Hibernia topsides design organization are shown on this slide. The use of CAD is an integral part of the design work of the project; all engineering disciplines producing design and construction deliverables are assigned within a conventional organizational structure. Separate groups of the project provide technical assistance and expertise to the design effort, both with regard to data processing, system and user support. The CAD System Support Manager, Duncan Pearce, has assisted in the preparation of this paper and is available for answering any questions you may have in that area.

3. 3D CAD MODEL SCOPE

The 3D CAD model will be built comprising Equipment, Piping, Electrical/Instrumental racks, HVAC ducts, Architectural walls and doors, Structural steel and Services support steel.

Output from the model will provide material and weight take-off reports for bulk items together with layout and general arrangement drawings.

4. PROCEDURES

As I mentioned in my introduction, working procedures adopted for Hibernia are similar to those utilized in Europe on comparable projects. The European experience has essentially been based on the PDMS and CALMA systems, whereas the Hibernia project is to be designed using the Intergraph PDS System. The engineering management principles involved in the use of all these systems are quite similar. This paper largely concentrates on these similarities though there are fundamental differences in the systems and software applications which must be reflected in specific project procedures, to ensure all staff are working to the same parameters.

The major CAD activity which has been in progress since the commencement of the project last October, has been the development of these working procedures. To ensure correctness of downstream operations it is necessary for discipline supervisors and their immediate deputies to fully appreciate the working of the CAD systems. The training and familiarization of this level of staff is just as important and perhaps more so than operators who will actually input to the CAD system.

The approach taken to staff training on Hibernia has been in the main to set up an in-house training facility with instructors being provided by Intergraph and from our own resources. Up to six workstations have been allocated for staff training, some of which takes place on a shift basis.

5). CLASS STRUCTURE

In order to effectively manage the Engineering effort a defined hierarchy of components for model build is adopted. This involves classification of all components into four major groupings as shown on this slide. The Class Structure is applied across all of the disciplines involved. Piping components are classified according to line size and structural according to functional classification of steelwork. Other disciplines, (Instruments, Electrical, HVAC, Mechanical, Architectural and Loss Control) follow a similar approach dependant on component size.

The principle adopted is that the "Class A" components are modelled first and interference checking of these components is carried on in parallel with the modelling of the "Class B" components. This process is repeated for each of the four classes.

6. WORKING SEQUENCE

The sequence of operations throughout all disciplines are similar and fall into the following major stages: Layout studies, Catalogue creation, CAD modelling, Interference checking and Drawing production. Periodic updates to modelled components are made to reflect available data. Each of these is followed by further interference checking prior to drawing production. I will now describe in some detail each of these phases.

6.1 Layout Studies

Conceptual layout studies can be produced manually or on a CAD system. The choice largely depends on the trained staff available at the commencement of the project. The decision was taken on Hibernia to initiate layout work manually and progressively phase it out over the course of the project, as a greater experience in the use of the CAD tools is acquired. A similar approach was adopted on the earlier North Sea projects.

A 1:50 Scale plastic block model has been constructed to assist in visualization of the facilities.

6.2 Catalogue Creation

The establishment of the catalogue of components which are used to form the CAD model is a most important CAD activity. For the Hibernia project a basic catalogue was provided by Intergraph and this was supplemented by existing specifications from within the Parent companies of the NOC consortium. It is essential that special attention is given to catalogue creation as there can be major consequences of changing catalogue components later in the detail design period. The fundamental engineering principles of establishing a firm base for proceeding with detailed design is absolutely applicable to CAD catalogue creation.

Thus piping specifications, which are subjected to development to suit the process design must be completed early to ensure pipework modelling can proceed to schedule. To achieve maximum efficiency in the use of CAD, the code numbering within the CAD model is identical to that of the database used on Hibernia for material control purposes. Thus complex "look up" tables are not required.

Likewise. the geometry of cable rack components must be defined. This may involve pre-selection of acceptable rack vendors because of geometry differences between suppliers products.

The volumetric space to be allocated to instrument valve actuators, is a critical area to which attention must be given early in the detail design phase.

6.3 CAD Modelling

In order to effectively manage the CAD model, the Hibernia platform has been split into five separate CAD projects, with model sub-partitions corresponding to primary steel deck divisions, as shown on this slide.

To ensure accountability of a given designer we have chosen to work to geographical splits of pipes with each designer modelling to an agreed match line rather than a piping systems split. Once all portions of a given line are determined to be clash free, the ends of sections may be adjusted to ensure proper spool break points appear on construction isometrics. This is based on our experience on similar North Sea projects.

6.4 Design Review

The Intergraph "walk-through" REVIEW Facility is utilized as part of the on-going day-to-day co-ordination between engineering disciplines. A special conference room with overhead projection facilities is set up within the design area. On previous projects considerable economonies and clarification of requirements have been achieved using such systems, particularly during the detailing of congested areas. Similar benefits are anticipated on Hibernia.

6.5 Interference Checking

The most important benefit to the Client in the use of CAD is to improve the quality of the design by enabling spacial co-ordination of components to be absolutely defined. This is particularly important on an offshore platform, where in order to minimize cost, the facilities must be designed in a compact manner, whilst still satisfying the necessary maintenance and operational criteria.

Working to such constraints, different disciplines inevitably will attempt to position components within the same volumetric space. Such inconsistencies, if discovered during fabrication onshore have very high rework costs, whilst any discovered offshore involve extremely high costs. A primary responsibility of the designer is to protect the client from such exposure and thus the interference checking facilities become a vital component of the management of the 3D CAD model.

This slide shows a sample alpha-numeric interference check report, and this slide shows a typical conversion to a graphical output. Clash pictures such as this are distributed to the responsible designers in the affected discipline and an agreed course of action to resolve the clash is thus facilitated.

Many of these clashes are in fact acceptable as, for example, they involve overlapping access ways, equipment sitting on steel work, pipes penetrating walls and pipes resting on support steel work. Once these acceptable clashes have been identified and logged in the system the remaining clashes must be resolved by means of negotiations between the relevant designers.

6.6 Model update.

The model build strategy which I described earlier on has to be re-visited and updated during the design cycle, particularly to incorporate vendor technical data.

Initial modelling of equipment is typically carried out utilizing information provided on process and mechanical data sheets. These are usually in simple block or volume envelope form.

This is then updated to reflect information received in the bidding period from the selected vendor. The layout constraints of any offshore platform result in the spacial requirements of vendor equipment being a significant feature of technical bid evaluations.

The extent of modelling at the final stage includes all nozzle connections and finalization of access volumes required for maintenance and withdrawal of any components.

This update philosophy is carried out to most components of the model. This slide (from a previous project) shows an HVAC ducting system, part of which is still in block form and part fully detailed.

6.7 Drawing Production.

Dependant on whether the module fabricators have CAD facilities, it may be appropriate to duplicate and/or transfer the CAD facilities to the fabrication site. Indeed, current North Sea projects have found great benefit in doing so.

The designer's prime responsibility however is for the production of traditional engineering drawings which module fabricators can easily use in his fabrication shops. The elimination of extended site design work gives significant schedule benefits to the ultimate client.

With modelling being carried out full-size, drawings can be pulled off at any convenient scale. The practicality of operating a design office, however, dictates that for maximum efficiency, the scales and match lines chosen for co-ordination drawings should be to the same basis for all disciplines.

The following slides give some typical examples of drawings produced on CAD, though obviously because of the early status of the Hibernia project some of these are taken from previous projects, engineered by the Parent companies. The use of isometric views has been found to be of great assistance to fabricators.

7. PROGRESS REPORTING

For those managers who have not been subject in their working experiences to hands-on use of a CAD facility, the problem of reporting progress is perhaps somewhat daunting. The perception which can exist is that work is keyed into the computer system by a multitude of draftsmen and hopefully at the end of the day some drawings are produced. In no way does this science need to be so vague.

We have adopted the approach on North Sea projects and repeated it on Hibernia, with specific CAD activities being separately identified within the main project control system.

This slide shows a typical extract from the critical path network of the Hibernia project. The CAD activities are: Studies, Catalogue creation, CAD Modelling, Clash Resolution, Drawing Production. All of these components have separate manhour budgets and progress must be measured in an appropriate manner.

The initial manual study drawings would be progressed using conventional drawing office practises.

The CAD modelling work is progressed by monitoring achievement of standard progress bench marks dependant on the stage of the design. This nextg slide shows typical bench marks used for piping components. You will see that the bulk of the work is carried out at the initial modelling stage but the updates which I outlined earlier are also assigned a standard percent complete bench mark. Thus the overall progress of CAD modelling by Class and Information status can be measured against a defined plan, as shown on this slide.

Separate reporting is maintained for clash resolution and as I mentioned before, a separate manhour budget is established for this. We have found that clash resolution is best measured at each of the distinct phases I described earlier on. The resolution of clashes can be measured and achievement of a given stage identified by means of a gradually reducing number of interferences, as shown here.

8. HARDWARE SET-UP

I will close my paper by giving you a brief summary of the hardware set-up on the Hibernia Topsides project. This comprises Intergraph UNIX based dual-screen workstations being driven by major VAX CPU's to handle all 3D CAD operations, with additional stand-alone 2D CAD terminals which also use the major CPU's as file servers. In addition, the project has also installed in excess of 17Gb of disk storage capacity for CAD data.

Large size plotted deliverables are produced on electrostatic plotters, whilst A and B size (European A4/A3) plots are directed to a number of laser printer/plotter devices.

As I mentioned earlier, the project makes use of Intergraph's REVIEW facility which runs on a separate UNIX based workstation.

Finally, the system configuration also includes communications links for CAD drawing transfers between our offices in Montreal and St. John's, where 2D CAD drafting is carried out on PC's using a small VAX CPU as a file server.

9. CONCLUSION

Finally, I would conclude the paper by summarizing for you the highlights.

Procedures are a most important front end activity to which time and management attention must be given; the organization of the CAD activity in a structured manner is a fundamental feature of the design process; the medium used for the initial studies is dependant on CAD skills available; creation of catalogues on a sound basis is essential; modelling is carried out on an area basis with a defined method for update to suit design development; interference checking due to the compact plant arrangement is essential prior to fabrication drawing production; fully accountable progress measurement methods are possible.

Utilization of CAD will give overall benefits to the project by providing a quality engineering product within the constraints of the project schedule and geared to fabricators needs.

Thank you for attention. I hope you found the paper interesting. Both myself and Duncan Pearce will do our best to answer any questions you may have.

THE DESIGN OF THE
HIBERNIA TOPSIDES
USING 3D - CAD

D. Langford

St. John's, Newfoundland

18 June, 1991

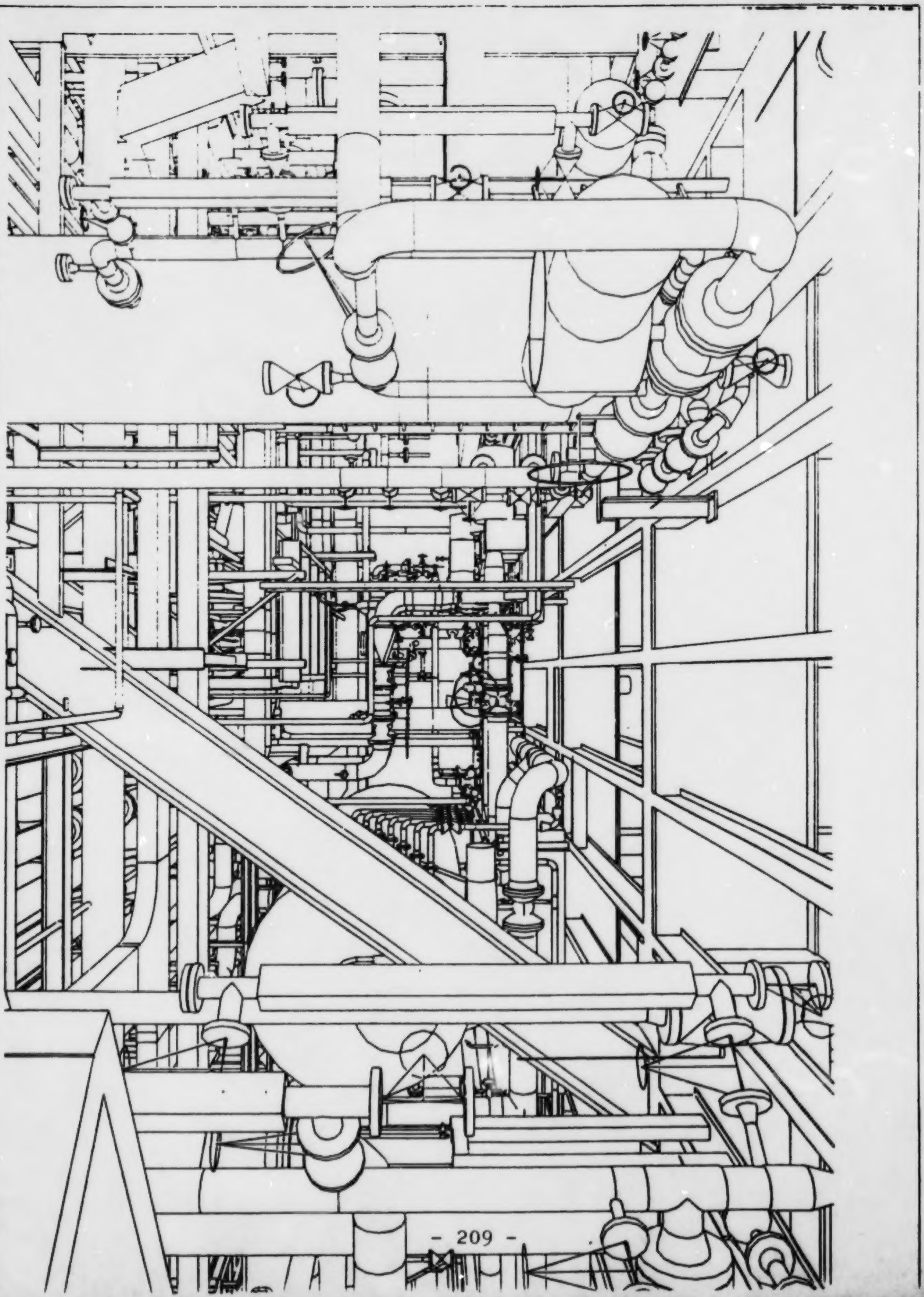
INTRODUCTION

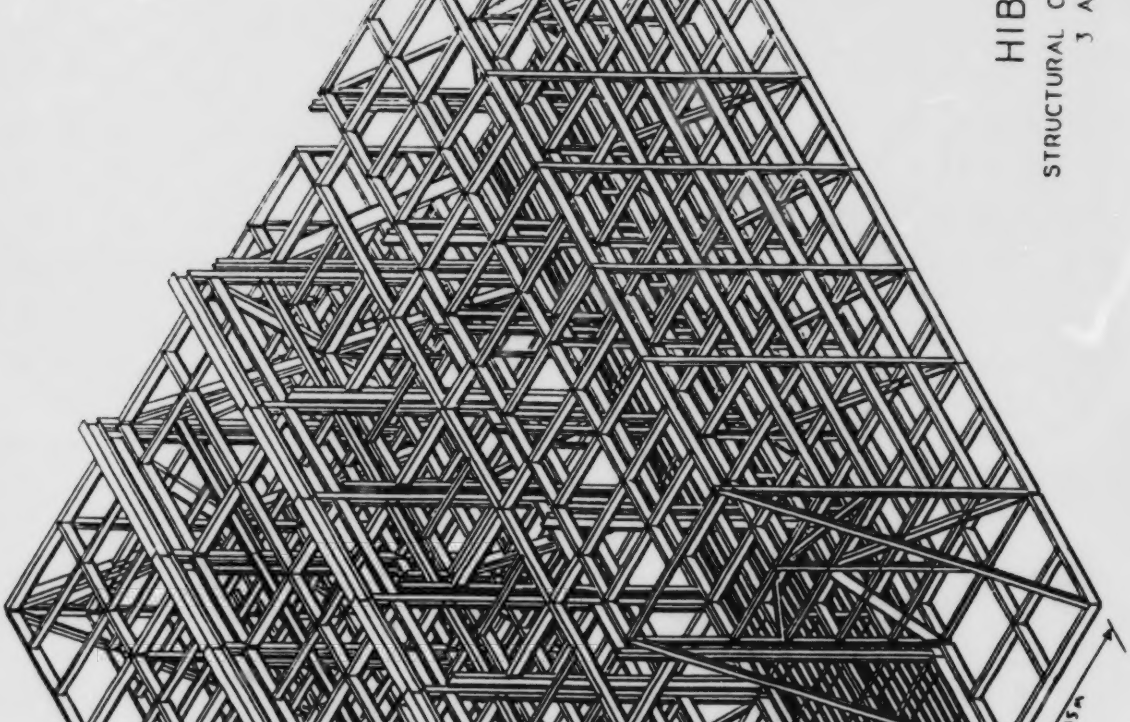
CAD SET UP PROCEDURES

WORKING SEQUENCE

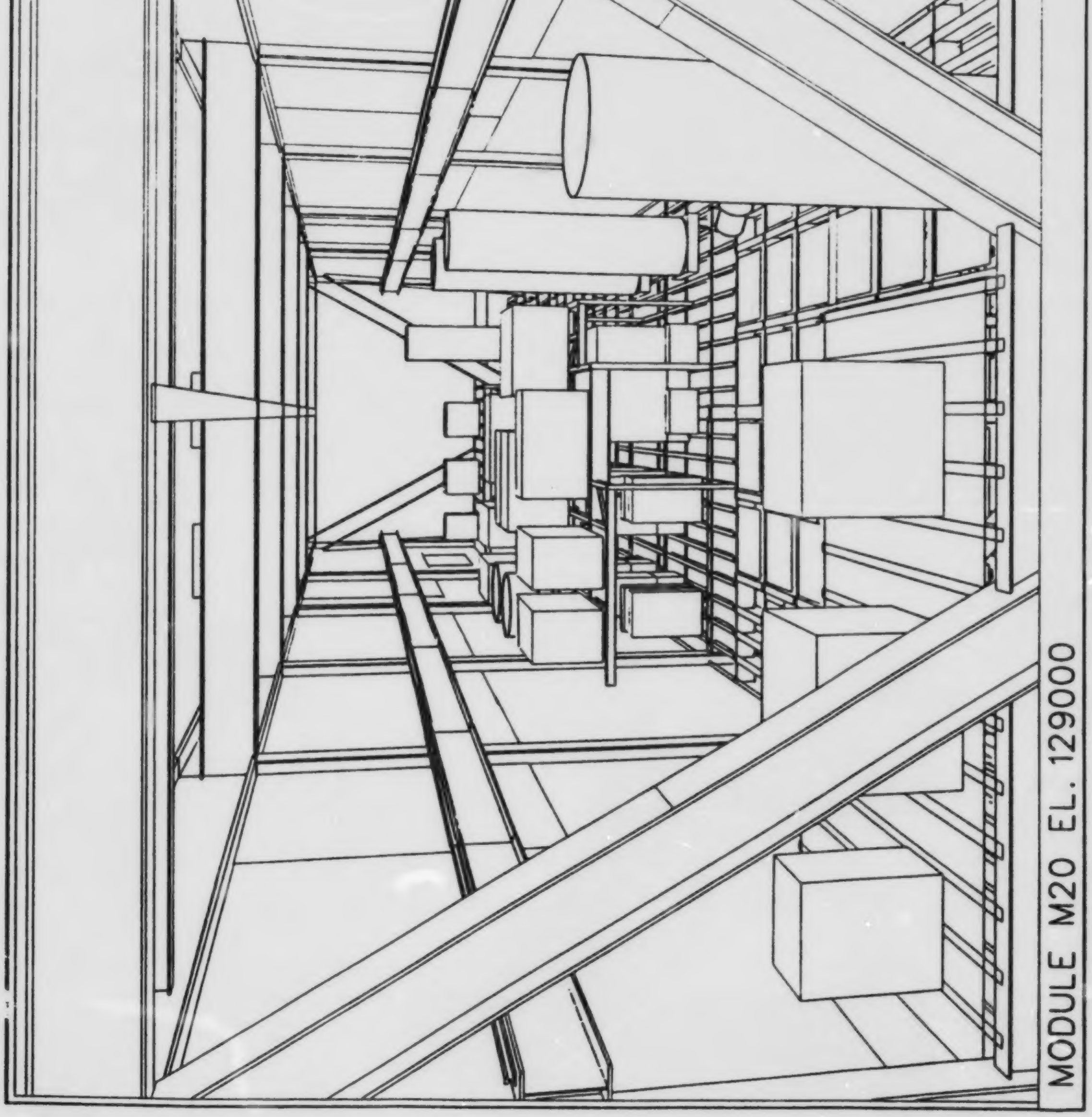
PROGRESS REPORTING

HARDWARE CONFIGURATION





HIBERNIA
STRUCTURAL CAD MODEL STATUS
3 APRIL 91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INTERFERENCE CHECKING

COMPACT ARRANGEMENT

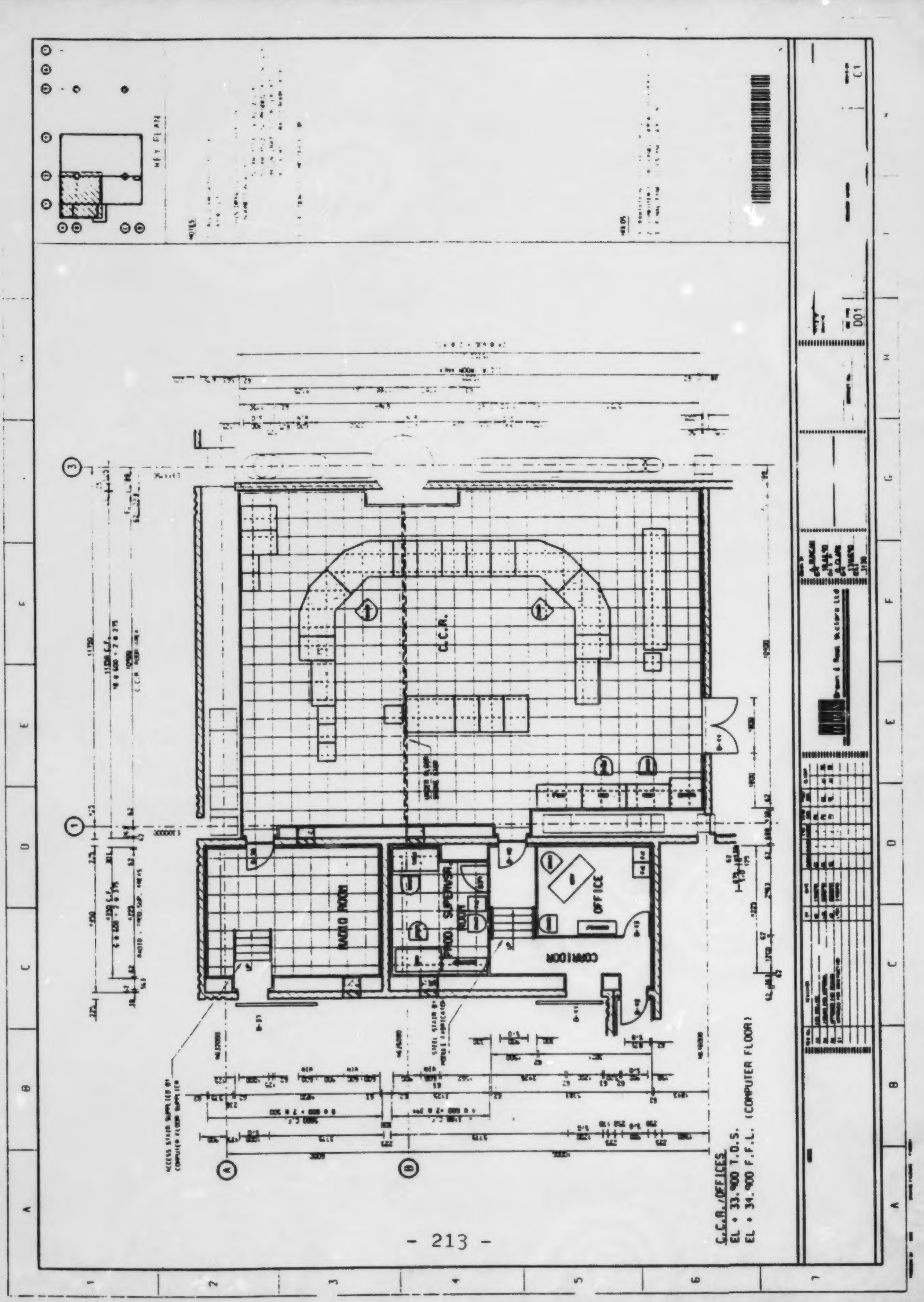
SPACE COORDINATION

OPERATIONAL AND MAINTENANCE REQUIREMENTS

FABRICATION REWORK AVOIDANCE

CLASH REPORTS

6.5


C.C.R./OFFICES
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SPEAKER : **NICOLAS PARSLOE**

COMPANY : **NEWFOUNDLAND OFFSHORE DEVELOPMENT CORPORATION - NODECO**

LOCATION: **ST. JOHN'S, NEWFOUNDLAND**

TOPIC : **UNIQUE TECHNICAL ASPECTS RELATED TO THE DESIGN OF THE HIBERNIA GBS STRUCTURE**

BIOGRAPHY: Mr. Parsloe was born in England where he received a Bachelor of Science Engineering Degree from the University of London. He has also attained a Certificate of Higher Studies at the Ecole Nationale des Ponts et Chaussee of Paris.

Mr. Parsloe is a Senior Project Engineer at DORIS Engineering. DORIS is the member firm with the GBS engineering design experience of NODECO joint venture.

Mr. Parsloe is responsible for the post processing of finite element analysis results. He is also responsible for the GBS engineering computer system set up, the implementation of an in-house database to manage the data from subcontractors, and all concrete design programs.

Mr. Parsloe has been involved in wave loading analysis and structural design of various concrete structures for the North Sea, as well as assuming significant responsibilities for the Ekofisk Protective Barrier Project and Ekofisk Tank Project.

NOIA CONFERENCE 91

A GRAVITY BASE STRUCTURE FOR THE HIBERNIA FIELD

F. Sédillot / T.L. Huynh

NODECO

PRESENTED BY: NICOLAS PARSLOE

June 1991

PAPERS PROPOSAL

Newfoundland Ocean Industries Association

"A GRAVITY BASE STRUCTURE FOR THE HIBERNIA FIELD"

ABSTRACT

A Gravity Base Structure (GBS) has been selected by HMDC (Hibernia Management and Development Company) as a fixed oil production platform for the Grand Banks in the Hibernia Field at about 200 miles offshore Newfoundland, in 80 m waterdepth.

This paper is intended to present the main particular aspects of the concrete structure proposed by NODECO (Newfoundland Offshore Development Constructors).

The GBS is planned to be the center of the oil production field, with a storage capacity of 1.3 million of barrels (209,000 m^3). The structure is designed to resist the 100 year storm wave and the impacts of icebergs prevailing in the Grand Banks. The 100 year storm wave has a maximum height of 29.3 m and an associated period of 18 sec. The design iceberg has a return period of 500 year.

The structure is mainly composed of a concrete caisson with an overall diameter of 105 m, and a height of 85 m. From the inside of the caisson, four cylindrical shafts project above the sea level up to 111.2 m high to support a steel deck which carries 55,000 tons of equipment.

The caisson presents on the external side, 16 teeth. The teeth form the external wall of the GBS and are connected to an internal circular wall, by a series of diagonals.

This particular configuration is chosen to resist the iceberg impacts of various shapes hitting under various incidences. Quite independent of the interior structure configuration, the external wall arrangement is provided to allow the crushing of the iceberg on the teeth and to spread the impact loads to the foundation soil. The horizontal force associated with the design level iceberg equals 500 MN and can be applied at any location, with a local pressure of 6 MPa.

The design of the GBS will be supported by several global 3D Finite Element Analyses. The ultimate load capacity of the external wall will be determined by local non-linear analyses.

The calculation of the wave forces on the GBS, and the associated wave model tests, the evaluation of the number of icebergs hitting the structure, and the determination of the iceberg impact loads are other outstanding aspects in the design of the GBS, and will be described.

Some indications on the GBS construction aspects will be also provided.

NODECO

7 June 1991

A GRAVITY BASE STRUCTURE
FOR THE HIBERNIA FIELD

CONTENTS

INTRODUCTION 1

1 DESCRIPTION OF THE GRAVITY BASE STRUCTURE 2

2 SOME ASPECTS OF THE GBS ANALYSIS 7

3 SOME INDICATIONS ABOUT GBS CONSTRUCTION 14

CONCLUSION 16

ACKNOWLEDGEMENTS 16

INTRODUCTION

A gravity base structure (GBS) has been selected by HMDC (Hibernia Management and Development Company) as a fixed production platform for the Grand Banks in the Hibernia field, about 315 kilometres offshore Newfoundland, in 80 m waterdepth.

The proposed GBS is planned to be the center of the oil/gas production field, being a drilling, production, storage and accommodation platform. It is required to include the following facilities and functions : (Fig. 1)

- drilling for 64 wells, enclosed in two separate shafts.
- collecting point for production from subsea manifolds.
- production, separation and treatment (150,000 BOPD).
- storage of 1.3 Millions barrels of crude oil (209,000 m^3).
- crude oil off-loading (at a rate of 8.800 m^3/hr).
- export of gas through pipelines to shore.
- injection of gas and water to wells on GBS and subsea manifolds.

This paper is intended to present some main aspects of the concrete gravity base structure proposed by NODECO (Newfoundland Offshore Development Constructors).

1 DESCRIPTION OF THE GRAVITY BASE STRUCTURE

1.1 General

The GBS consists mainly of a cylindrical caisson, which rests on the sea bottom, and of four columns extending above the sea level to support the topsides facilities. These columns are the continuation of shafts, located within the caisson (Fig. 2).

The caisson is a cylindrical hull, closed at the bottom and the top by horizontal slabs.

The outer vertical wall (icewall) which defines the cylindrical hull is composed of 16 identical teeth placed around the caisson.

The teeth are connected to an internal circular wall - which encloses the oil storage volume - by a series of diagonal walls.

The whole arrangement is believed to constitute an efficient mean to spread the local iceberg loads as well as to reduce the global iceberg forces.

The internal area of the hull is used as the crude oil storage volume. It is divided into independent compartments by internal diaphragms and the 4 circular shafts. These walls extend from bottom to top of caisson.

1.2 Base Slab

The base slab is supported by a pattern of orthogonal beams of about 0.70 m to 0.90 m thick and 9.0 m high, with a spacing of 9 to 10 m. This slab is formed with ribs and haunches so as to minimize the concrete volume. The thickness of the slab varies in general from 1.20 m at the slab edges to about 0.80 m at the central part (Fig. 3).

The base slab is prestressed in the two directions. It extends outside the icewall. Its nearly circular shape is actually a 16 side polygon. This particular shape has been selected to facilitate placing of prestressing cable anchors.

Special attention is given to the intersection of the slab with the vertical conductor pipes. Plugs are formed by non reinforced concrete which is poured together with the surrounding slab. The concrete is thus monolithic in the area of the intersection.

The base slab forms the support to various piping systems : risers, J tubes, as well as piping for operation of the storage facilities. The base slab is fitted with 0.60 m high ribs and 2.0 m high concrete skirts, which protrude from the underneath of the base slab and cut into the soil so as to increase the stability of the foundation under installation and operating conditions. During the platform installation phase, the platform will sit on the skirts and ribs, thus preventing hard point effect on the base slab. Upon installation of the GBS, the volume between the soil and the slab, and enclosed within the skirts, is filled with grout to insure a full contact between the base and the foundation soil (Fig. 4).

1.3 Internal Area

The internal walls of the caisson form an internal core which is connected to the external icewall at four locations. This structural arrangement allows the internal core to be quite independent of the external area (Fig. 5).

The internal core comprises the four shafts and six flat walls (diaphragms).

The four shafts include the two drill shafts (which, in operation, communicate with the sea), the riser shaft (which can be dewatered), and the utility shaft (which is permanently dry).

Three independent storage reservoirs with a total capacity of 209.000 m^3 are provided inside the internal area.

The pressure in the crude oil storage compartments is controlled by a ballast water tank, whose level is kept constant at El + 90 m. The storage cells are thus in overpressure with respect to the surrounding water ballast cells and to the sea.

Prestressing cables, laid horizontally and vertically in the walls compensate for this overpressure. These cables also provide the necessary compression to keep the effect of temperature within allowable limits.

The thickness of the walls in the internal area varies between 0.60 m to 0.80 m, depending on the differential pressure on the faces and on the axial forces in the section.

1.4 Icewall

The icewall is at the periphery of the caisson. It consists of 16 teeth, the tip of which is rounded to minimize any local effect which might damage the concrete.

The tip of the tooth, which is expected to be hit first by the iceberg will cause the ice to progressively crush (Fig. 6).

The number and size of the teeth and their shape are the result of a compromise between several factors :

- the minimization of the global iceberg force applied to the GBS.
- the spreading of the local iceberg load both in horizontal and vertical directions.
- the facility of the construction with a reduced number of nodes and of elements meeting at the same node.

The internal forces developed under the iceberg impacts are high axial forces and bending moments. The icewall has a thickness of 1.40 m, the diagonals 0.70 m to 0.95 m. and the inner wall 0.90 m. on most of the caisson height.

1.5 Shafts and Legs

The GBS is fitted with four shafts with a center to center distance of 31.18 m in the W.E. direction and of 37.0 m in the N.S. direction. Between the base slab and the roof, the four shafts are circular with the same internal diameter (16.90 m). The two drill shafts are located on the North of platform. Each drill shaft shelters 32 conductor pipes, equally spaced with a distance of 2.5 m center to center. These two shafts are flooded with sea water and are in communication with the sea. The two other shafts on the South are the utility shaft, which is permanently dry and the riser shaft, which normally is filled with sea water but may be emptied for maintenance purposes (Fig. 7).

The part of the shafts above the caisson roof constitutes the columns which support the topsides deck at El 111.2 m. The columns are shaved off to include two flat sides. This arrangement has been selected to decrease the distance between the external side of the shafts, and render the deck mating operation easier. The top of the shafts presents a local thickening on which the deck support frame transition pieces will rest. The shafts are also fitted with steel deflectors which are intended to prevent major effects from wave run-up on the deck (Fig. 8).

1.6 Roof

At level 85.0, a slab of 0.60 m thick closes the caisson. It is supported by the vertical walls and by beams of 0.70 m wide and 5.0 m high. Spanning between the beams, open web joists support 0.10 m thick precast elements, used as formwork to pour the remainder of the slab.

Manholes are placed in each slab element, which covers a cell receiving offshore solid ballast. These manholes are sealed before deck mating and upon completion of the offshore solid ballasting operation (Fig. 9).

1.7 Solid Ballast

In order to achieve the required stability during tow and the final apparent weight at the final site, inshore and offshore solid ballasts are incorporated into the GBS.

Solid ballast placed inshore (82.600 t) at the bottom of the storage cells, up to level + 11.0 approximately, except in the shafts, provide stability for the GBS during towing and installation phases. Inshore solid ballast has a saturated density of 3200 kg/m^3.

Solid ballast placed offshore (530.100 t), up to level + 65.0 approximately, in the cells formed by the circular latticed system provides additional weight to resist the environmental loads (waves and icebergs). Offshore solid ballast has a saturated density of 3200 kg/m^3.

1.8 Storage

Three independent storage compartments are arranged between the internal circular wall and the four shafts. Each compartment has an area of 1.000 m^2 approximately, giving a total area of 2.990 m^2 (Fig. 10).

The total volume available for crude oil storage is 1.3 Millions barrels (209.000 m^3).

GBS - PRINCIPAL CHARACTERISTICS

Waterdepth (MLW)	80.00 m
Overall caisson diameter measured at tip of teeth	105.00 m
Overall caisson height at periphery above sea bed	85.00 m
Base slab equivalent diameter	106.60 m
Level at top of legs	111.20 m above seabed
Concrete volume involved	162.000 m^3
Crude oil storage volume	209.000 m^3
Topsides weight	550.000 kN
Apparent weight of GBS on Site (minimum)	6.500.000 kN

2 SOME ASPECTS OF THE GBS ANALYSIS

2.1 Loads

The GBS is subjected to many load cases as it can be normally expected :

- permanent loads : dead weight, hydrostatic pressure, solid ballast pressure, etc...
- functional loads : differential oil/water pressures and associated thermal loads.
- environmental loads : waves, wind, current, iceberg.
- construction loads.

Wave loads

The wave loads are calculated on the basis of a deterministic approach using diffraction programs and checked against basin model tests. The design wave, defined for the 100 y return period has the following characteristics :

Maximum wave height	H = 29.3 m
Periods	T = 15 to 18 s

The experience gained in previous analyses combined with the results of model tests performed in 1984, allows an accurate assessment of the wave forces, both globally and locally (on the shafts).

The maximum wave forces, acting on the GBS are found to be at mudline level :

Maximum horizontal force	F = 1.750 MN
Overturning moment	M = 69.727 MNm

Iceberg loads

The iceberg load analysis has been carried out using an approach specified by HMDC. The basic steps of this approach are as follows : (Fig. 11)

- simulation of iceberg parameters, such as number of icebergs hitting the structure, iceberg mass, diameter, velocity, impact eccentricity, etc...

- calculation of iceberg loads based on above data and storage of results.

- statistical analysis of results and production of exceedence probability distributions and return period curves.

To obtain the iceberg parameters, the Monte-Carlo distribution sampling technique is used. In this method, a random number between 0 and 1 is generated independently for each parameter and set equal to the probability of exceedence for that parameter. Then, the value of each input parameter is selected corresponding to the randomly selected exceedence probability. Thus the iceberg mass, radius, velocity, relative eccentricity, etc... are randomly generated.

From these data, the energy of the iceberg impact may be calculated, and the force, moment, torsion due to the impact are determined, based on the volume of ice which must be crushed to absorb the impact energy.

Random simulations of iceberg occurrences are performed for a simulation period of 200.000 years and the design and safety level iceberg loads are selected from the output. The entire simulation is repeated several times using different starting assumptions (seeds) for the generation of the random data. The results have been found very stable.

Two types of icebergs are considered for the design :

- a design level iceberg with a 500 y return period
- a safety level iceberg with a 10.000 y return period

The forces thus obtained are globally multiplied by a factor of 1.05 to account for the simultaneous occurrence of waves. The iceberg is assumed to hit the GBS at any level and any location, giving a horizontal force (FH), an overturning moment (M) and a torsional moment (T) at the base of the GBS. The iceberg loads may be summarized as follows :

Class	Design Parameter	Results	
Design level iceberg	FH max M max T max	503 31,870 13,240	MN MNm MNm
Safety level iceberg	FH max M max T max	1,333 84,450 35,090	MN MNm MNm

It may be noted that the global horizontal force which governs the design of the foundation is due to the wave loads.

The iceberg impact load F is considered to be applied at any location with a local pressure p (MPa) which is given by the following formula

$$p = 6 \sqrt{1 + \frac{2,4}{A}}$$

where A (m^2) is the area of the iceberg impact, projected on a plane perpendicular to the direction of the impact.

Project impact areas are of the order of 100 m^2 for the design level iceberg and 260 m^2 for the safety level iceberg.

In the 3D models, the iceberg loads are applied in the most severe configurations and particularly skew impacts have been considered by loading only one side of a single tooth, which is a much severe load case than a radial impact.

A coarse mesh 3D model has been run, using in-house structural computer package (Pafec) to determine the worst iceberg load configurations regarding both the icewall and the supporting walls behind the teeth. The selected icebergs are then generated and analysed in the final refined 3D model as mentioned above (Fig. 12).

In addition to iceberg impacts, growler impact loads of 5 MN over an area of 1 m^2 or greater have been considered for the local design of the caisson roof and shafts.

2.2 Structural Analysis

The Global Finite Element Models

The analysis of the GBS is performed using 2D and 3D Finite Element Models (F.E.M).

The analysis takes into account not only the operating phases but also the construction stages. Due to the size of the structure, the superelement technique is employed.

A complete 3D model M_0 is used for the in-place conditions. A second partial model M_1 which constitutes the lower part of the structure, is built up with a number of superelements from M_0. and is used for the construction stage conditions.

The model M_0 includes about 65.000 nodes, and is formed by 71 superelements (SE) of level 0 : (Fig. 13)

3 x 16	SE	from the 16 teeth
1 x 4	SE	from the base slab
1 x 4	SE	from the upper slab and upper shafts
2 x 4	SE	from the 4 shafts
2 x 3	SE	from the central 3 cross walls
1	SE	from the boundary conditions

The elements used are in general thick shell isoparametric quadrilateral elements with 8 nodes and 4 gaussian points. Each node has 6 degrees of freedom.

The different superelements are assembled together at different levels to form the global structure. There is a total of 10 levels of assembly.

Before the final selection of elements and properties to be used in the analysis, a number of tests has been performed consisting in :

- validation of thick shell element with variable thickness.
- validation of thick shell element with partial loadings.
- validation of base slab modelization.
- validation of the icewall modelization.

One of the most important problems is the modelization of the teeth. The teeth present at their nodes, large haunches which cannot be easily modeled with thick shell elements. Therefore two models of 3 teeth of 30 m high are prepared. The first one - the reference model - is made with 20 nodes solid elements. The second one is made with thick shell elements with a meshing which will be used later on the global model M_0. In order to obtain accurate results for comparison, the mesh of the reference model is made finer than the mesh of the second model. The final data used for model M_0 are determined by comparison with that of the reference model.

The Analyses of the Icewall

The load effects are determined, in the finite element analyses, in accordance with the linear elastic theory.

However, under the effect of iceberg loads, in ultimate limit state conditions, some areas of the icebelt are subjected to significant tensile membrane forces. Due to tension, the walls in these areas have their membrane stiffness reduced. To account for this stiffness reduction, the specifications have permitted for the tender design stages to apply a factor of 0.5 to the initial uncracked stiffness. For the present detailed design, the stiffness reduction assumptions are verified by comparison of internal stress and strain conditions for walls in tension to those of other walls. The analyses are performed as follows :

The initial F.E. analyses performed with uncracked concrete modulus of elasticity (Ec) provide the internal stress and strain conditions in the walls under the permanent and functional loads and the iceberg loads. Where tensile stress and strain are significant, a reduction factor (ϕ) of the initial stiffness is allowed.

The application of ϕ leads to a new stiffness distribution in the structure, i.e. a new distribution of internal stress and strain. The process is repeated so as at the end of the computations, the internal forces will correspond to the appropriate stiffness reduction factors which have been applied.

The reinforcement of the icewall is based on the final results of these analyses.

The Analysis Post-Processing

Results from the Finite Element Analyses represent a large volume of information relating to geometric data and analysis results. The treatment and management of that information requires the application of an automated computer-based environment.

For purposes of data management, a specific database has been created which will be loaded with geometry, forces and displacements from the F.E. analyses. The interface modules will be used to transform results from individual sub-structure/superelement data, into global results conforming to engineering conventions used on the project.

Once the database has been loaded, data processing modules are used to extract data for review of F.E. results and for use by the concrete design programs. These modules will support extraction of results for a given point, or a selection of points, within the GBS and provide selected printed and/or graphical presentations.

The code checking of the GBS

Various load combinations under serviceability limit states (SLS), ultimate limit states (ULS), and progressive collapse limit states (PLS) are computed at a number of selected groups of nodes of the GBS.

For each group of nodes and for each limit state (SLS, ULS, PLS), in house programs are run to obtain the envelope of forces to use for the design. At each group of nodes, the computer program gives the following sets of forces :

- Max Fxx   axial force in X direction and associate values
- Max Fyy   axial force in Y direction and associate values
- Max Fxy   in plane shear force and associate values
- Max Mxx   bending moment in X direction and associate values
- Max Myy   bending moment in Y direction and associate values
- Max Mxy   moment giving max in plane shear and associate values

Computer code checking programs are built up to check then the capability of the concrete and reinforcement sections to withstand the above sets of forces, in accordance with the project specifications (Fig. 14).

CONSEC : to calculate the reinforcement required for ultimate limit state design (ULS) and to check concrete/steel stresses and crack widths for serviceability limit state design (SLS).

CONSHR : to check transverse shear in ULS and provide required stirrup reinforcement area.

CONFAT : to perform fatigue checks for concrete and main reinforcement.

SHRFAT : to perform fatigue checks due to transverse shear on concrete and stirrups.

GBS - MATERIAL QUANTITIES

Concrete volume	162.000 m^3
Reinforcement steel	60.000 t
Prestressing steel	4.500 t
Solid ballast at tow-out (saturated @ 3.200 kg/m^3)	82.600 t
Offshore solid ballast (saturated @ 3.200 kg/m^3)	530.000 t

MATERIAL CHARACTERISTICS

Concrete :	
Strength at 28 days on cylinder	49 Mpa
Strength at 1 year	59 MPa
Reinforcement steel :	
. yield strength bars ∅ ≥ 35 mm	500 MPa
. yield strength stirrups ∅ ≤ 25	400 MPa
Prestressing steel : Strand 0.6"	
. grade : 270 ksi	
. area : 140 mm^2	
. breaking load	260.7 kN
. yield load at 0.1%	234.7 kN

3 SOME INDICATIONS ABOUT GBS CONSTRUCTION

The GBS construction can be split into two main phases (Fig. 15).
- construction of the base structure in the dry dock
- completion of the whole structure at the deep water site

3.1 Construction in dry dock

- The construction of the base structure in the dry dock involves
  . 34.000 m^3 of concrete
  . 13.000 t of reinforcement steel
  . 1.250 t of prestressing steel
  The dry dock has a depth of 13.80 m

- The concrete base slab is poured directly on the prepared surface of the dry dock. Following the levelling of the dry dock formation and the backfilling of the skirts trenches, a lean concrete layer of minimum thickness of 0.10 m is poured and levelled to form the soffit of the base slab. Prior to the placing of the reinforcement, a heavy duty polythene is placed over the entire area of lean concrete soffit. This is to prevent any grout loss into the underlaying layer and to help separation during the float out operation.

  The tower crane base areas are poured first, followed by the four perimeter areas and the two central areas. Concrete placing for each of the six major areas is performed in continuous operations (i.e. 24 hrs working) with an average pouring rate of 35 m^3/hr which ensures that the largest pours are completed within 48 hours.

- The construction of the walls is also divided into 6 areas.
  Walls are equipped with self-climbing jumpform.
  Although recognizing that the standard method of construction of offshore GBS platform is by slipforming, a careful investigation has led to the conclusion that jumpforming is the optimum solution for the present project, due to the high reinforcement ratio (450 kg/m^3) to be installed in the icewall, thus requiring a high manpower.
  Upon completion of works in the dry dock (Fig. 16),
  . The external walls of the icebelt are constructed to a constant level of + 20.0 m to provide a sufficient free-board to the structure.
  . The other walls of the icebelt are stopped at level + 10.0 m
  . The inner walls are jumpformed up to level + 10.0 m
  . All the base beams are completed.

- The fabrication and installation of the Mechanical Outfitting (MOF) in the base structure is not a small task, compared to the concrete works.
  In the base slab, a number of pipes related to the temporary and permanent mechanical systems (grouting, water exhaust) has to be simultaneously installed with the reinforcement bars and the prestressing cables.

  Above the base slab, a number of spool pieces are to be installed in the walls to allow crossing of risers and J-tubes.

3.2 Construction at deepwater site

Construction of the upper part of the structure is completed at deepwater site. The structure is progressively sinking under the added weight until it reaches the final draught.
During construction, the GBS is moored to 8 anchoring lines, some of which are provided with adjustments to compensate for changes in the geometry of anchor chains as the structure sinks.

Several barges are permanently moored around the GBS. They are used as storage areas for reinforcement steel, prestressing materials, miscellaneous jumpform equipment, pipesleeves and embedment items. A special barge is used to support the concrete pumps which deliver concrete to the GBS via several pipelines.

With the aim of reducing the working personnel on the platform during construction, while still achieving a high production rate, it is planned to maximize the use of prefabricated reinforcement cages for all walls and more particularly for the outer walls. Nodes, which are complicated, are constructed in-situ.

The maximum height of the cages is about 7.5 m and their weight does not exceed 15 t, which is in the range of the tower cranes capacity.

Pipe sleeves and embedded plates are preinstalled in the cages and have adjustable fixings where necessary to enable precise location when the cage is installed in its final position.

For the concreting operations, the structure is divided into 10 areas, and the concrete placing is performed symmetrically to keep the GBS vertical.

The maximum height of each concreting step is 1.5 m and the maximum volume of concrete to be poured in each phase is such that the maximum time for concreting is limited to 12 hrs. This permits a lift to be concreted even in periods of bad weather, provided there is a 12 hr window of fine weather available.

The construction at deep water site involves :

- 128.000 m^3 of concrete
- 47.000 t of reinforcement steel
- 3.750 t of prestressing steel

3.3. Marine operations and installation on site

The GBS concrete construction is completed with the placing of inshore solid ballast, necessary before the installation of the topsides on top of the shafts.
This topsides installation is a major marine operation, in which the weather is the governing factor. The operation is scheduled to take place in 72 hrs during which the weather must remain stable with :

- significant wave height less than 0.7 m
- 24 hrs forecast of wind less than Beaufort 3 for critical operations.

The final tow of the GBS fully equipped to the Hibernia field is another major marine operation and requires a towing fleet which includes approximately 6 main tugs of 16 000 IHP class, 1 escort vessel and 1 stand by tug.
The final tow is planned to take place in about 8-10 days.

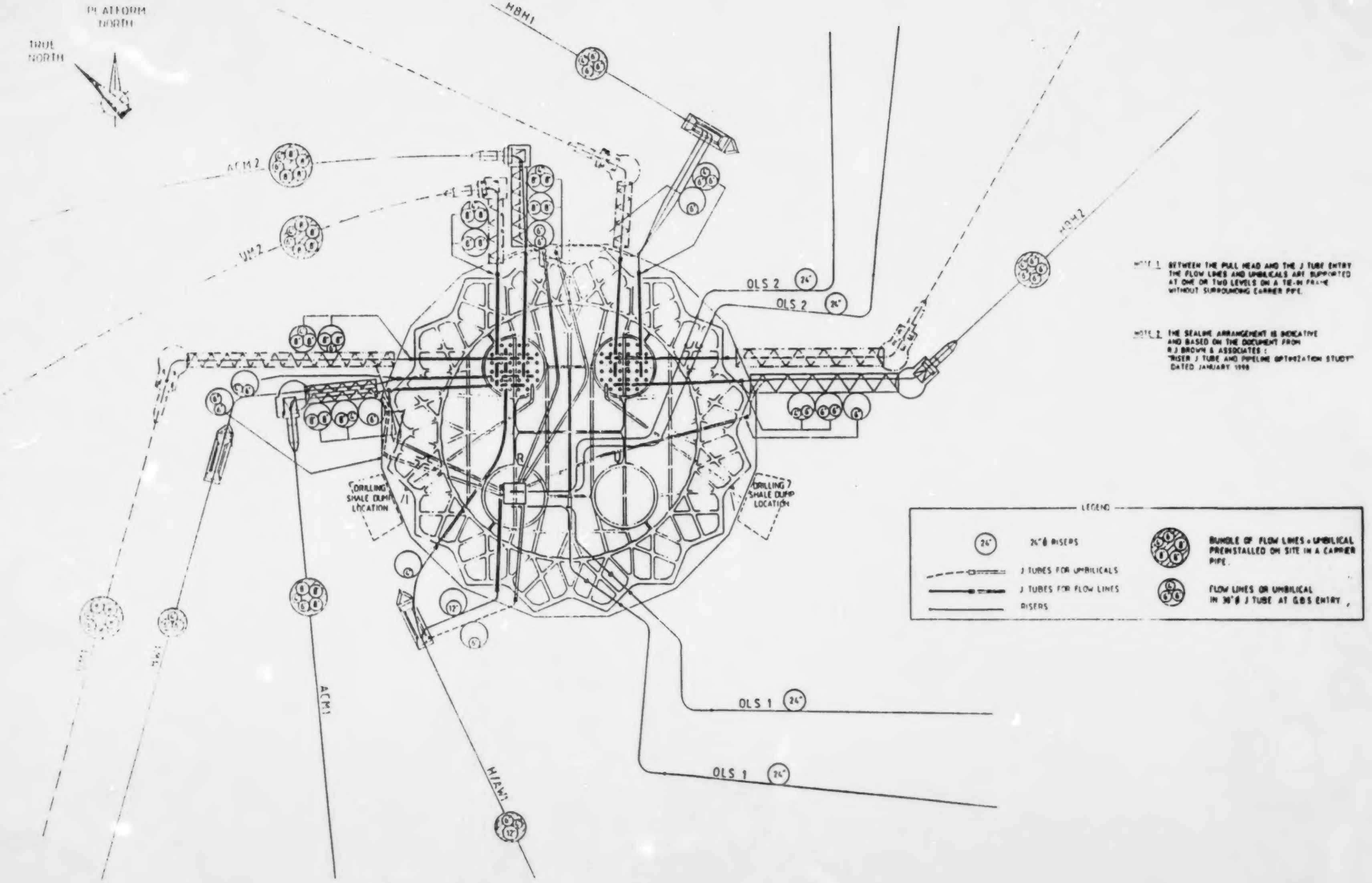
CONCLUSION

The present paper has described some main features of the analysis, design construction and installation of the gravity base structure developed by NODECO in response to HMDC specifications.

The design work is presently under progress.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge permission to publish this paper to Hibernia Management and Development Company (HMDC) and Newfoundland Offshore Development Constructors (NODECO) managements. They would like to thank the many colleagues within NODECO for their most valuable contribution to the analysis and design of the GBS.


PLATFORM NORTH
TRUE NORTH
MBH1
ACM2
UM2
OLS 2
24"
OLS 2
24"
MBH2
DRILLING / SHALE DUMP LOCATION
DRILLING / SHALE DUMP LOCATION
12"
6"
OLS 1
24"
OLS 1
24"
ACM1
HIAW1
12"
LEGEND
24"
24"Ø RISERS
J TUBES FOR UMBILICALS
J TUBES FOR FLOW LINES
RISERS
BUNDLE OF FLOW LINES + UMBILICAL PREINSTALLED ON SITE IN A CARRIER PIPE.
FLOW LINES OR UMBILICAL IN 30"Ø J TUBE AT G.B.S ENTRY.

NOTE 1 BETWEEN THE PULL HEAD AND THE J TUBE ENTRY THE FLOW LINES AND UMBILICALS ARE SUPPORTED AT ONE OR TWO LEVELS ON A TIE-IN FRAME WITHOUT SURROUNDING CARRIER PIPE.

NOTE 2 THE SEALINE ARRANGEMENT IS INDICATIVE AND BASED ON THE DOCUMENT FROM R J BROWN & ASSOCIATES : "RISER J TUBE AND PIPELINE OPTIMIZATION STUDY" DATED JANUARY 1990

FIGURE N°1

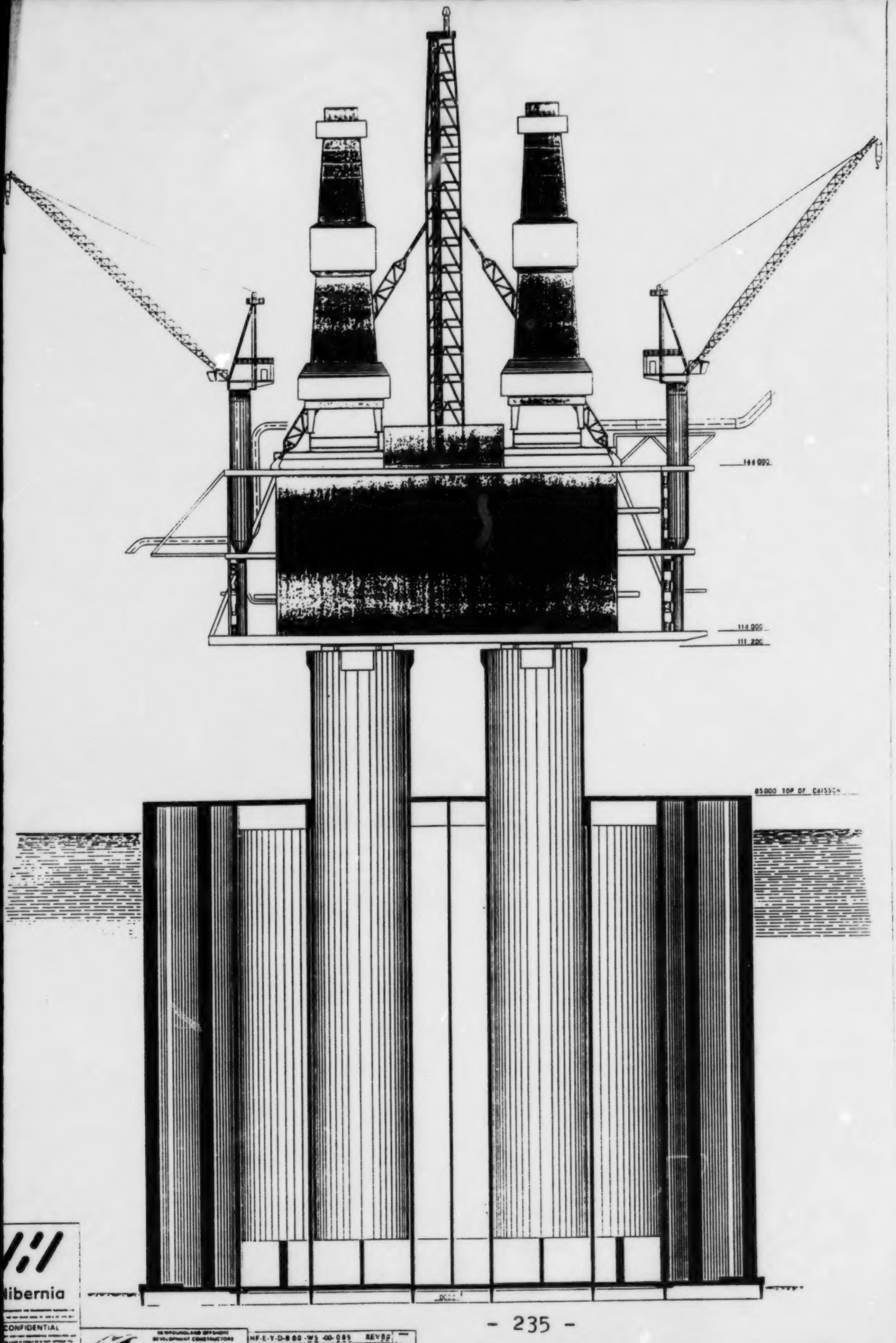

144 000
114 000
111 200
85000 TOP OF CAISSON
Hibernia
CONFIDENTIAL
NEWFOUNDLAND OFFSHORE
DEVELOPMENT CONSTRUCTORS
NF-E-Y-D-880-W2-00-085 REV 0
1/250

FIGURE N°2

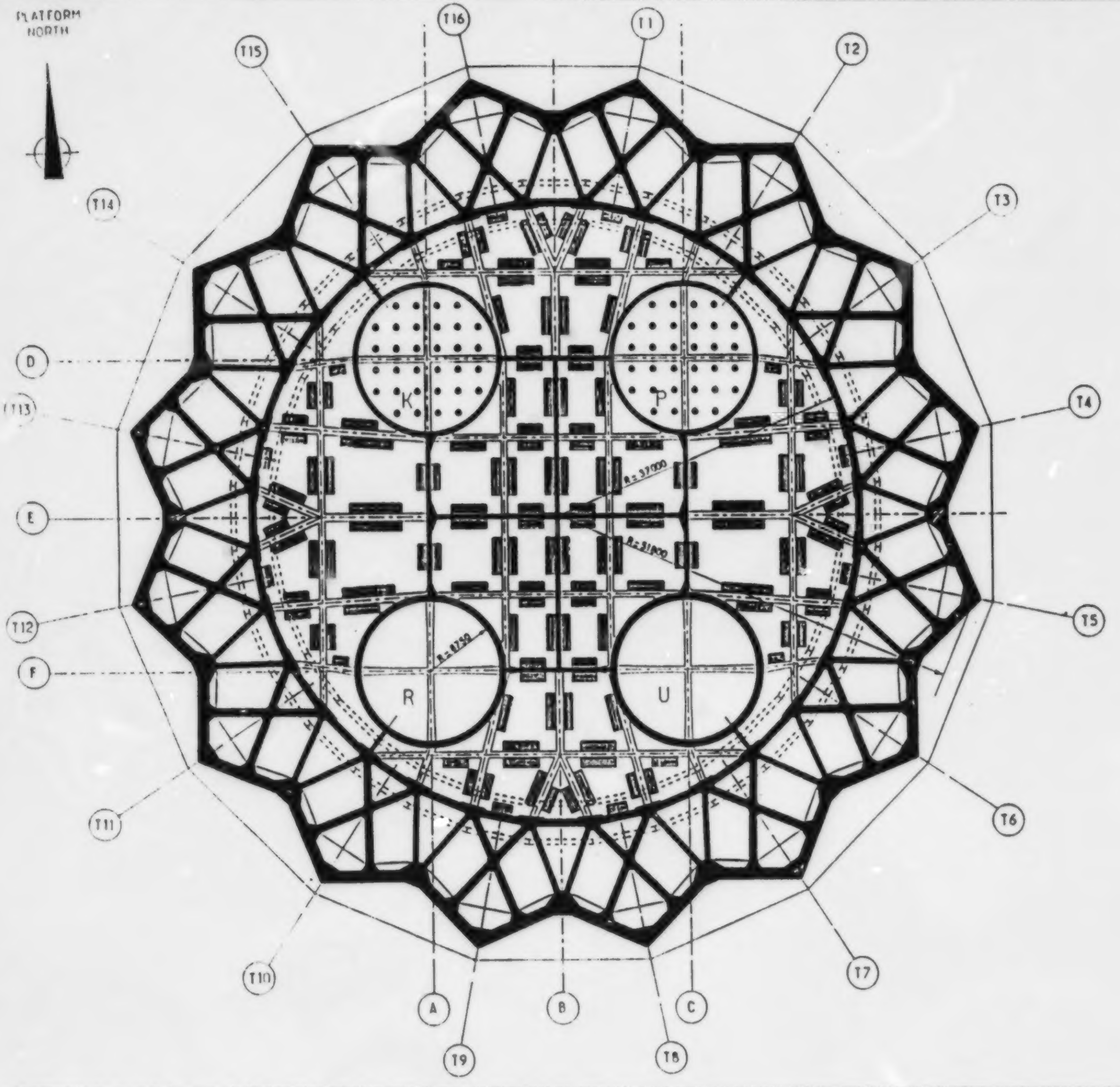

PLATFORM NORTH
T15
T16
T1
T2
T14
T3
D
T13
T4
E
T12
T5
F
T11
T6
T10
T7
A
B
C
T9
T8
K
P
R
U
R=37000
R=31800
R=8750

FIGURE N°3

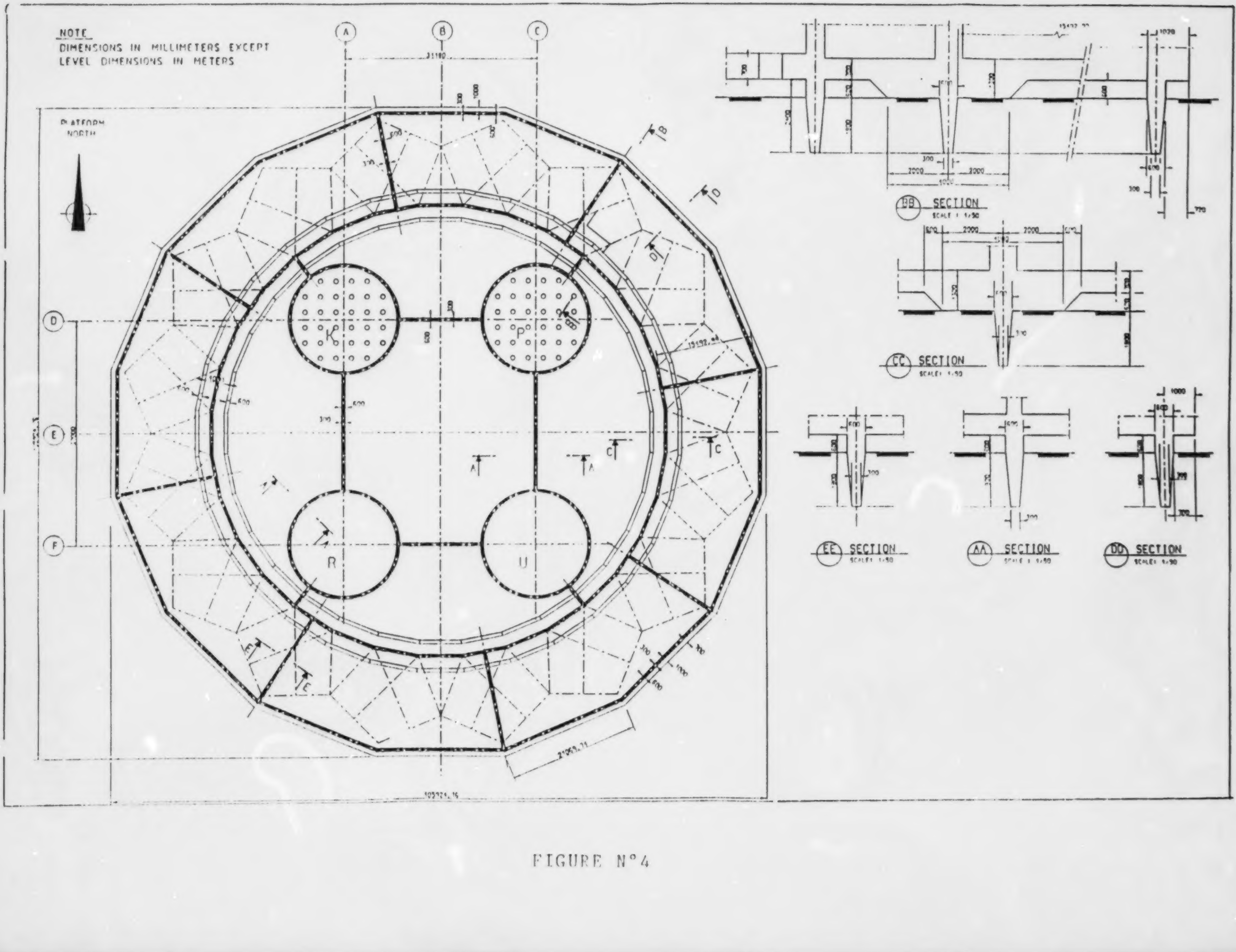
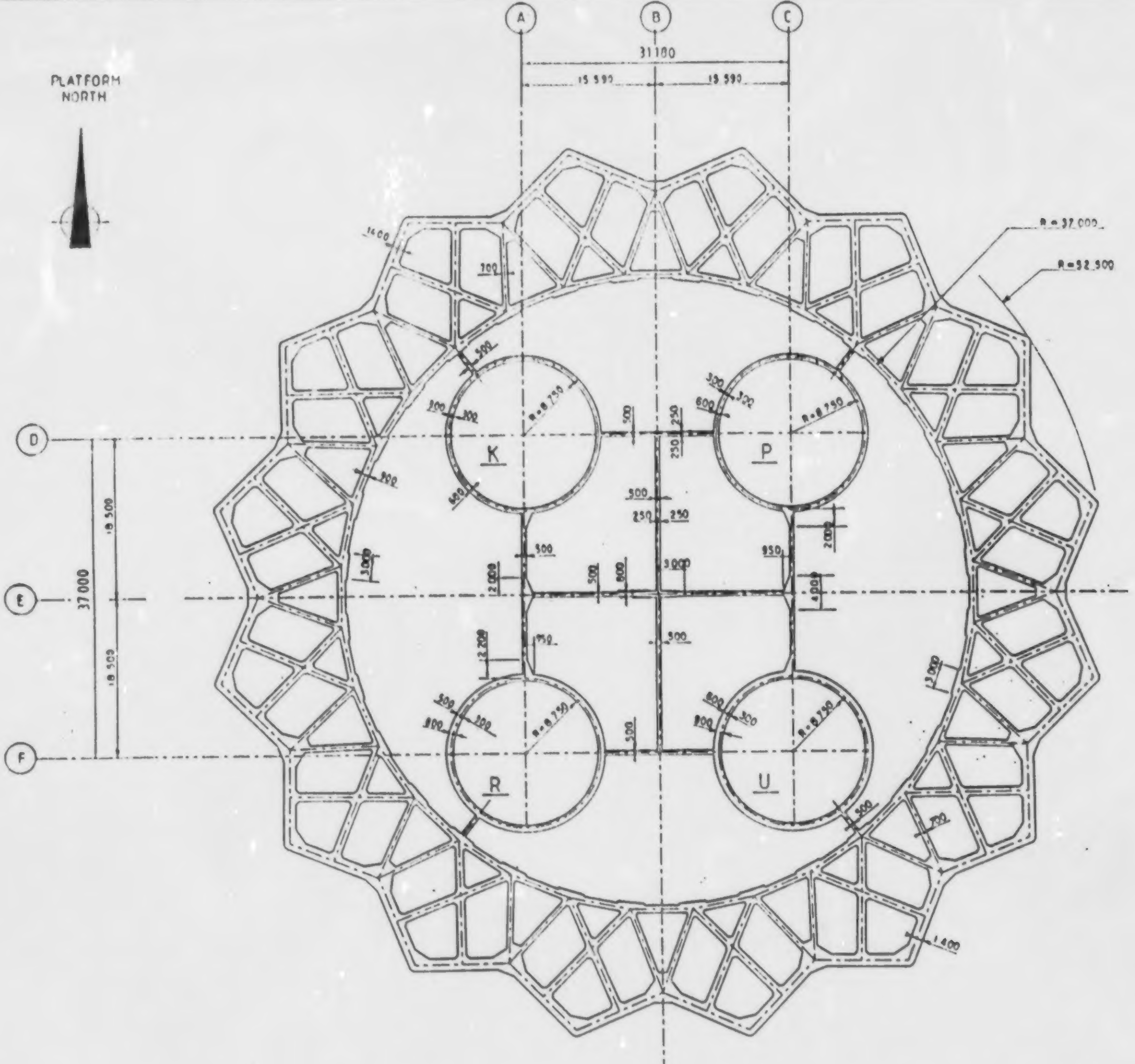

NOTE
DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS
PLATFORM
NORTH
A
B
C
D
E
F
31180
K
P
R
U
105924,16
21069,71
BB SECTION
SCALE 1:50
CC SECTION
SCALE 1:50
EE SECTION
SCALE 1:50
AA SECTION
SCALE 1:50
DD SECTION
SCALE 1:50

FIGURE N°4


A
B
C
31 100
15 590
15 590
PLATFORM
NORTH
D
E
F
37 000
18 500
18 500
K
P
R
U
R = 8 750
R = 37 000
R = 52 500
1400
700
500
300
600
800
250
3000
2000
4000
950
750

NOTE
- DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS

FIGURE N°5

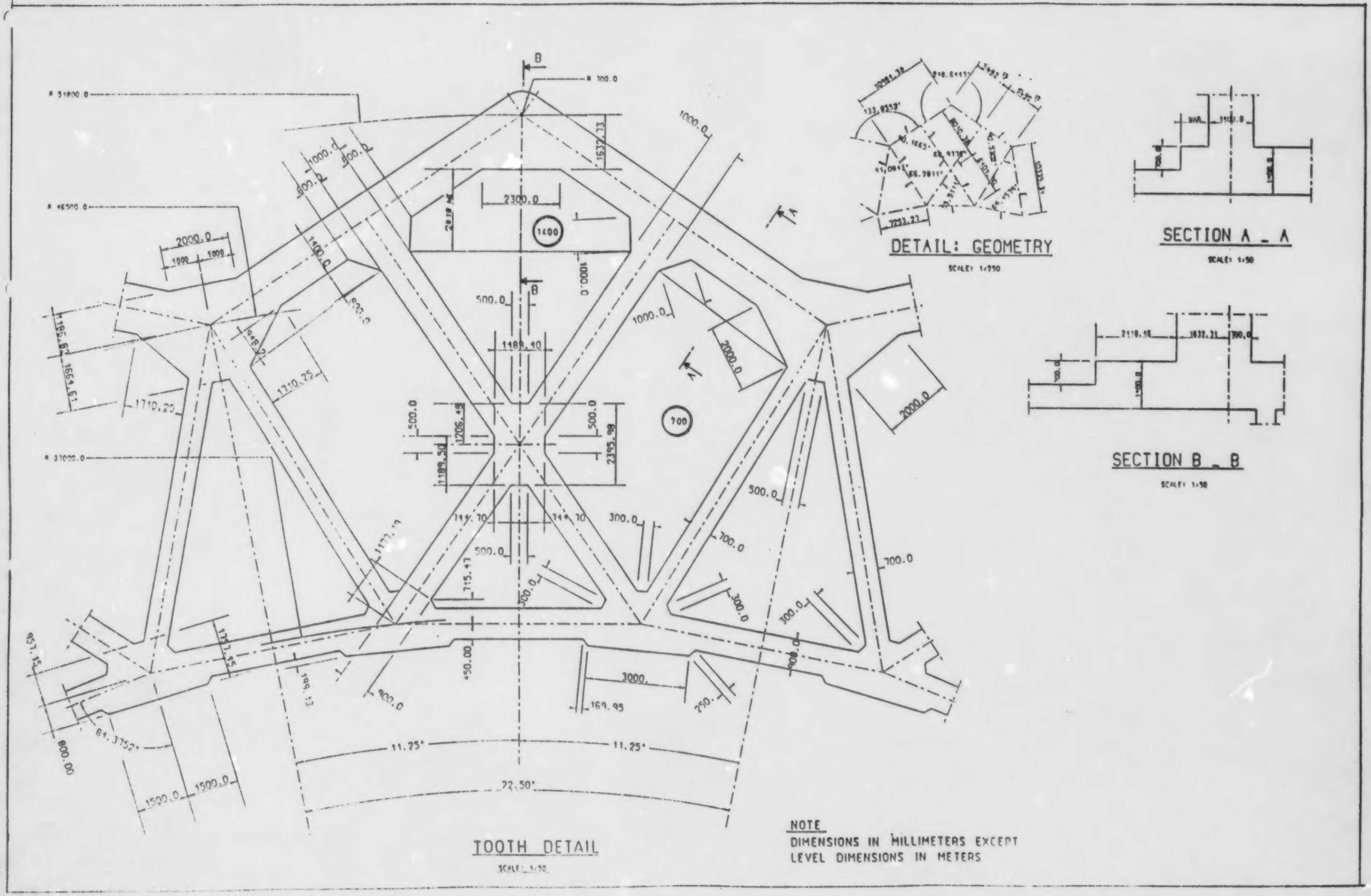

DETAIL: GEOMETRY
SCALE: 1:250
SECTION A _ A
SCALE: 1:50
SECTION B _ B
SCALE: 1:50
TOOTH DETAIL
SCALE: 1:50
NOTE
DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS
B
A
1400
700
2300.0
2000.0
1000
1000.0
900.0
500.0
700.0
300.0
250.
3000.
169.95
199.13
800.00
957.15
1500.0
84.3752°
11.25°
22.50°
1664.61
1710.25
1632.73
2395.98
1206.49
1189.50
1189.10
715.47
450.00

FIGURE N°6

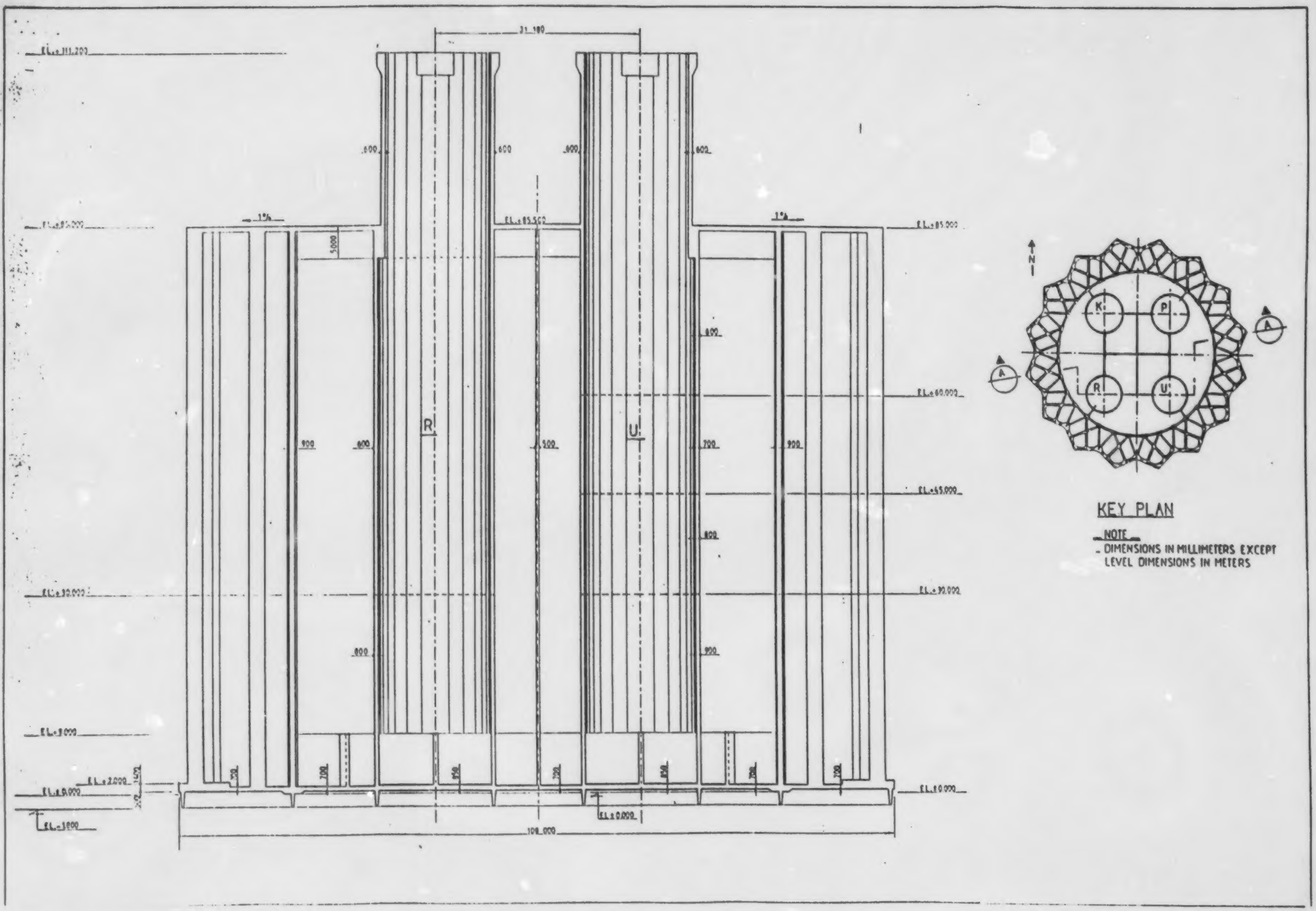
EL.+111.200
EL.+85.000
EL.+30.000
EL.+9.000
EL.+2.000
EL.±0.000
EL.-1.800
31.180
EL.+85.500
1%
5000
600
900
800
500
700
250
R
U
EL.+60.000
EL.+45.000
EL.±0.000
108.000
N
A
K
P
R
U
KEY PLAN
NOTE
- DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS

FIGURE N°7

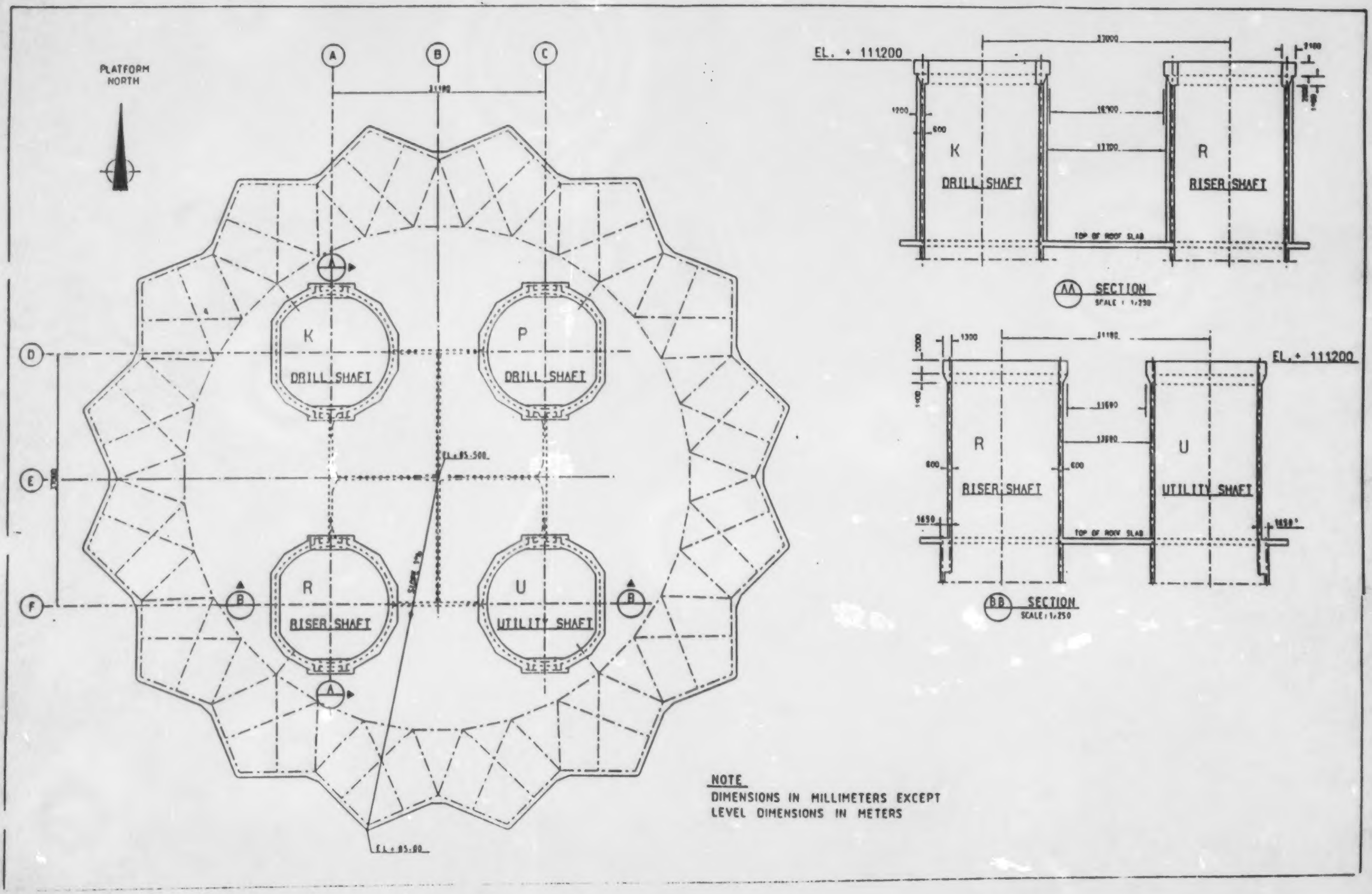

PLATFORM NORTH
A
B
C
D
E
F
31190
K
DRILL SHAFT
P
DRILL SHAFT
R
RISER SHAFT
U
UTILITY SHAFT
EL + 85.500
EL + 85.00
EL. + 111200
13000
16900
11100
1200
600
2100
TOP OF ROOF SLAB
AA SECTION
SCALE : 1/250
1300
31190
2000
1400
11690
13690
800
600
1650
1650
TOP OF ROOF SLAB
EL. + 111200
BB SECTION
SCALE : 1/250
NOTE
DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS

FIGURE N°8

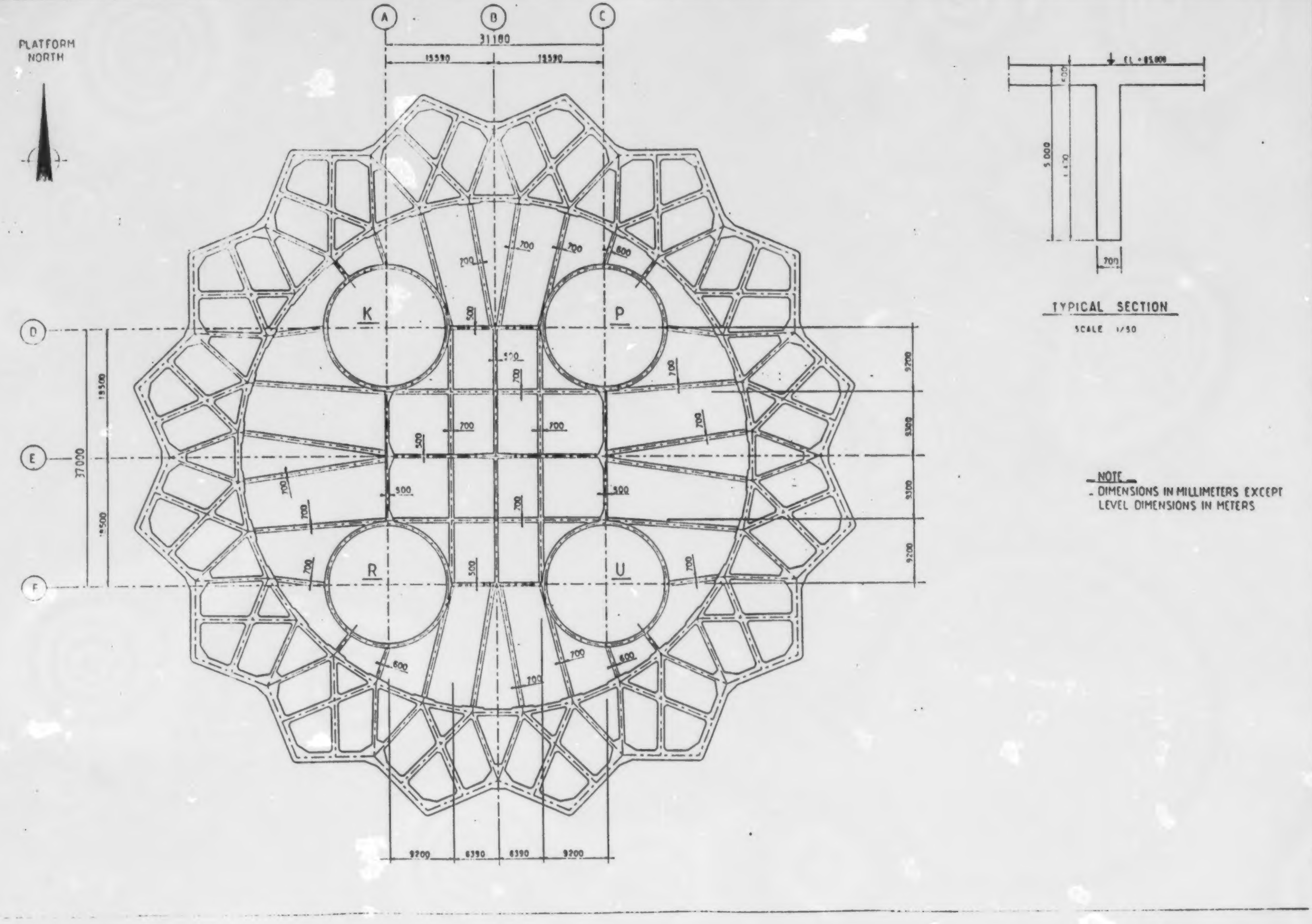
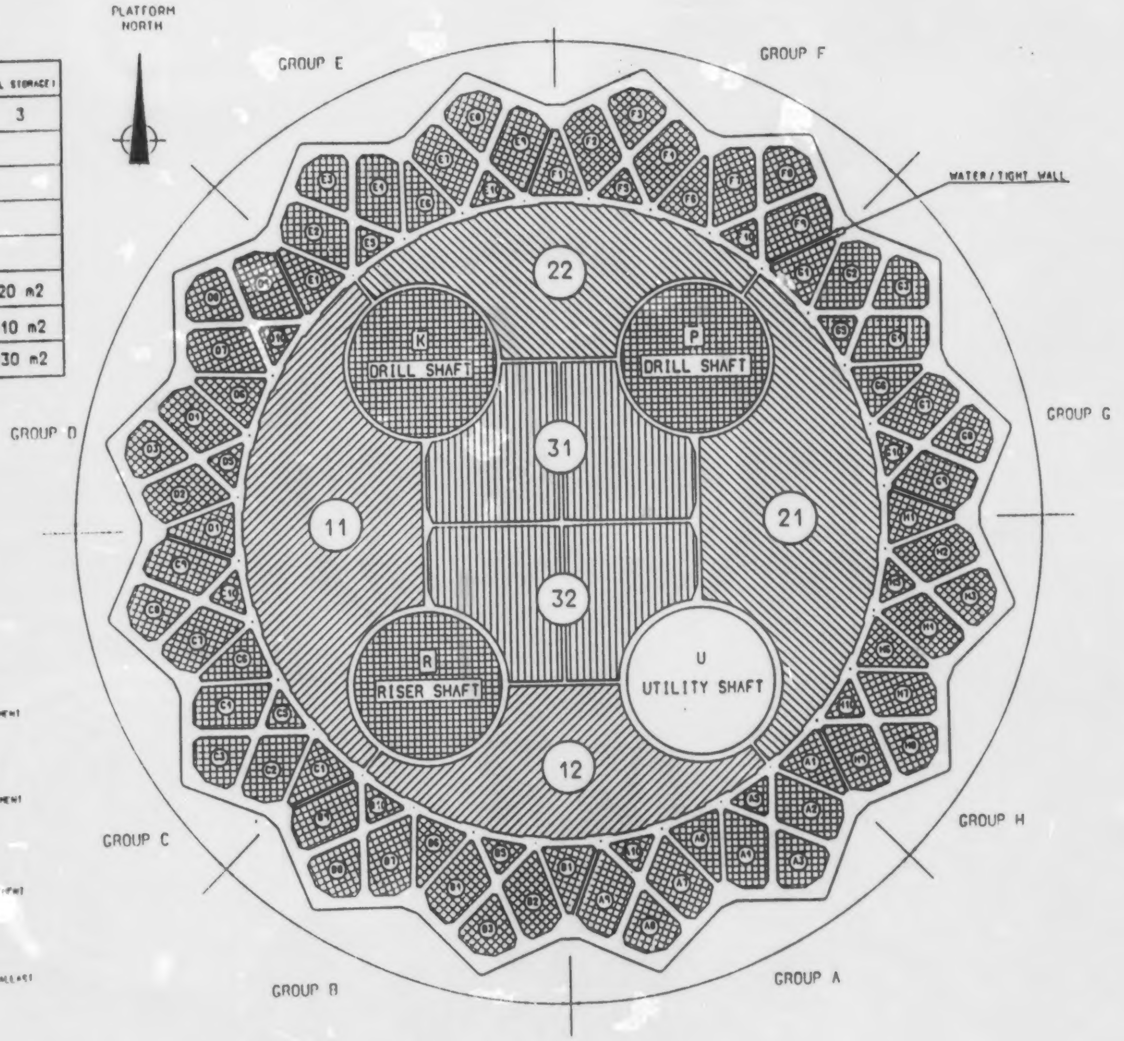

PLATFORM NORTH
A
B
C
31180
15590
15590
D
E
F
37000
18500
18500
K
P
R
U
500
700
600
9200
9300
9300
9200
9200
6390
6390
9200
EL +85.000
400
5.000
4.470
700
TYPICAL SECTION
SCALE 1/50
NOTE
- DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS

FIGURE N°9

CELL AREA (CRUDE OIL STORAGE)			
GROUP / CELL	1	2	3
11	645 m2		
12	425 m2		
21		650 m2	
22		440 m2	
31			420 m2
32			410 m2
	1070 m2	1090 m2	830 m2


PLATFORM NORTH
GROUP A
GROUP B
GROUP C
GROUP D
GROUP E
GROUP F
GROUP G
GROUP H
WATER / TIGHT WALL
K
DRILL SHAFT
P
DRILL SHAFT
R
RISER SHAFT
U
UTILITY SHAFT
11
12
21
22
31
32

LEGEND

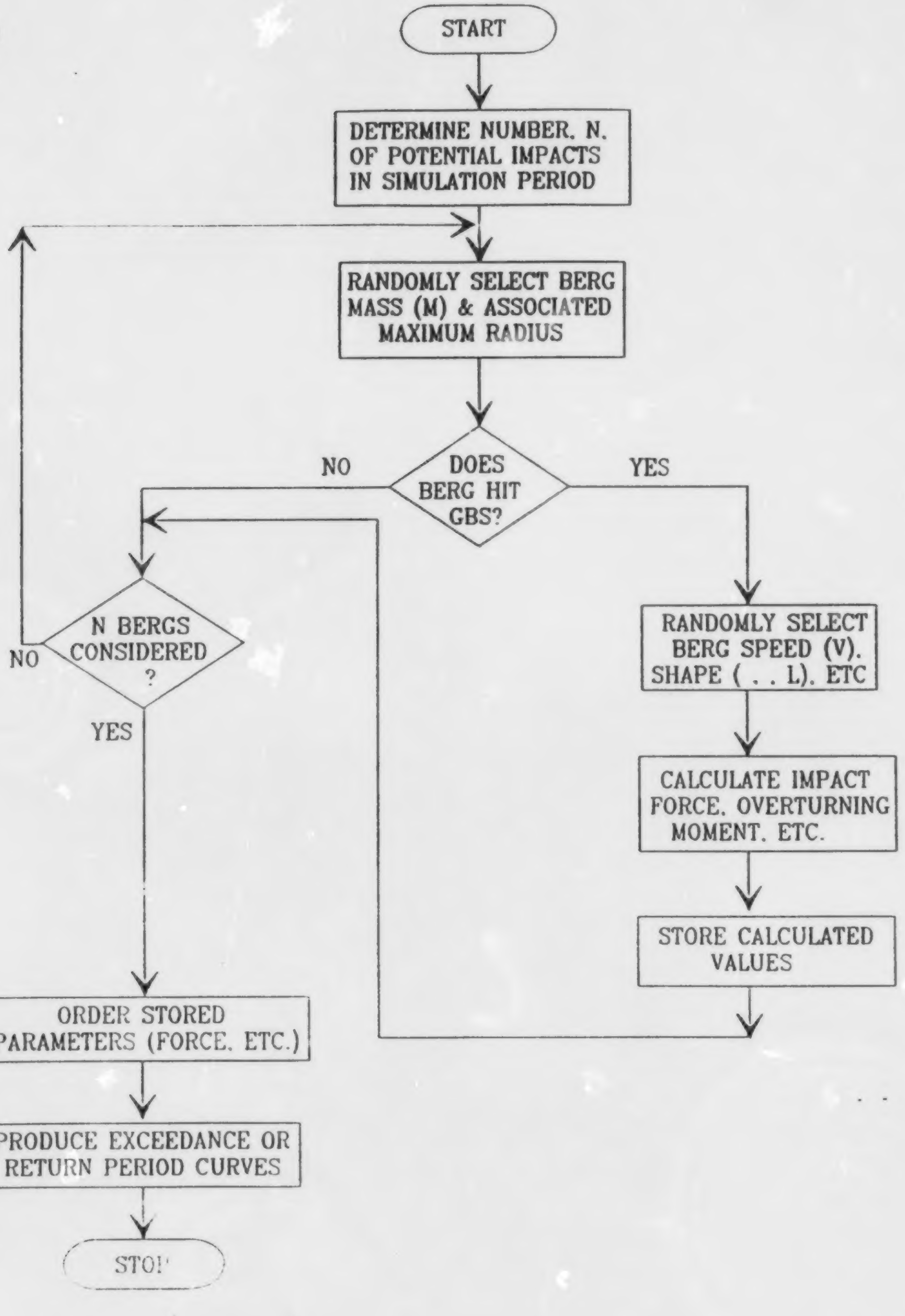
▨ CRUDE OIL 1st COMPARTMENT

▧ CRUDE OIL 2nd COMPARTMENT

▥ CRUDE OIL 3rd COMPARTMENT

▦ SEA WATER / SOLID BALLAST

FIGURE N°10

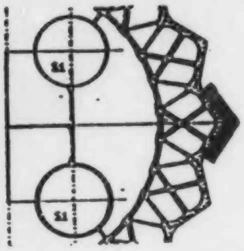

START
DETERMINE NUMBER, N, OF POTENTIAL IMPACTS IN SIMULATION PERIOD
RANDOMLY SELECT BERG MASS (M) & ASSOCIATED MAXIMUM RADIUS
DOES BERG HIT GBS?
NO
YES
N BERGS CONSIDERED ?
NO
YES
RANDOMLY SELECT BERG SPEED (V), SHAPE (. . L), ETC
CALCULATE IMPACT FORCE, OVERTURNING MOMENT, ETC.
STORE CALCULATED VALUES
ORDER STORED PARAMETERS (FORCE, ETC.)
PRODUCE EXCEEDANCE OR RETURN PERIOD CURVES
STOP

Flow Chart of Simulation

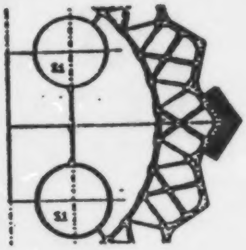
FIGURE N° 11

Load cases investigated :

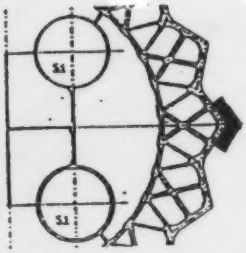
LC : U1



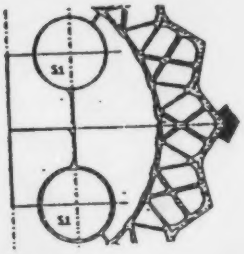
LC : U2



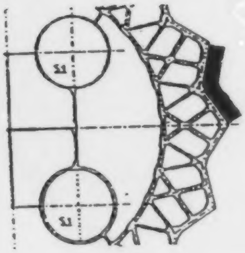
LC : U3



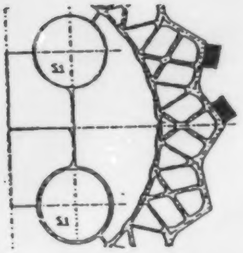
LC : U4



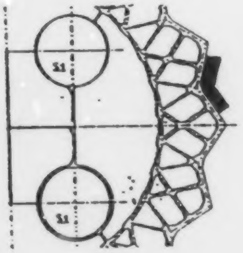
LC : U5



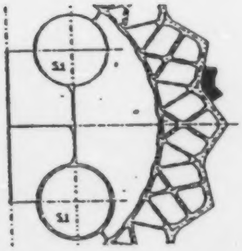
LC : U6



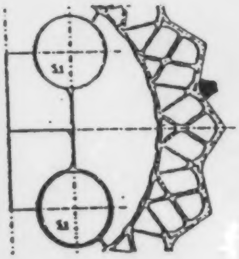
LC : U7



LC : U8



LC : U9



LC : U10

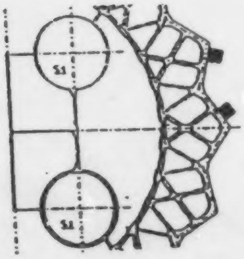
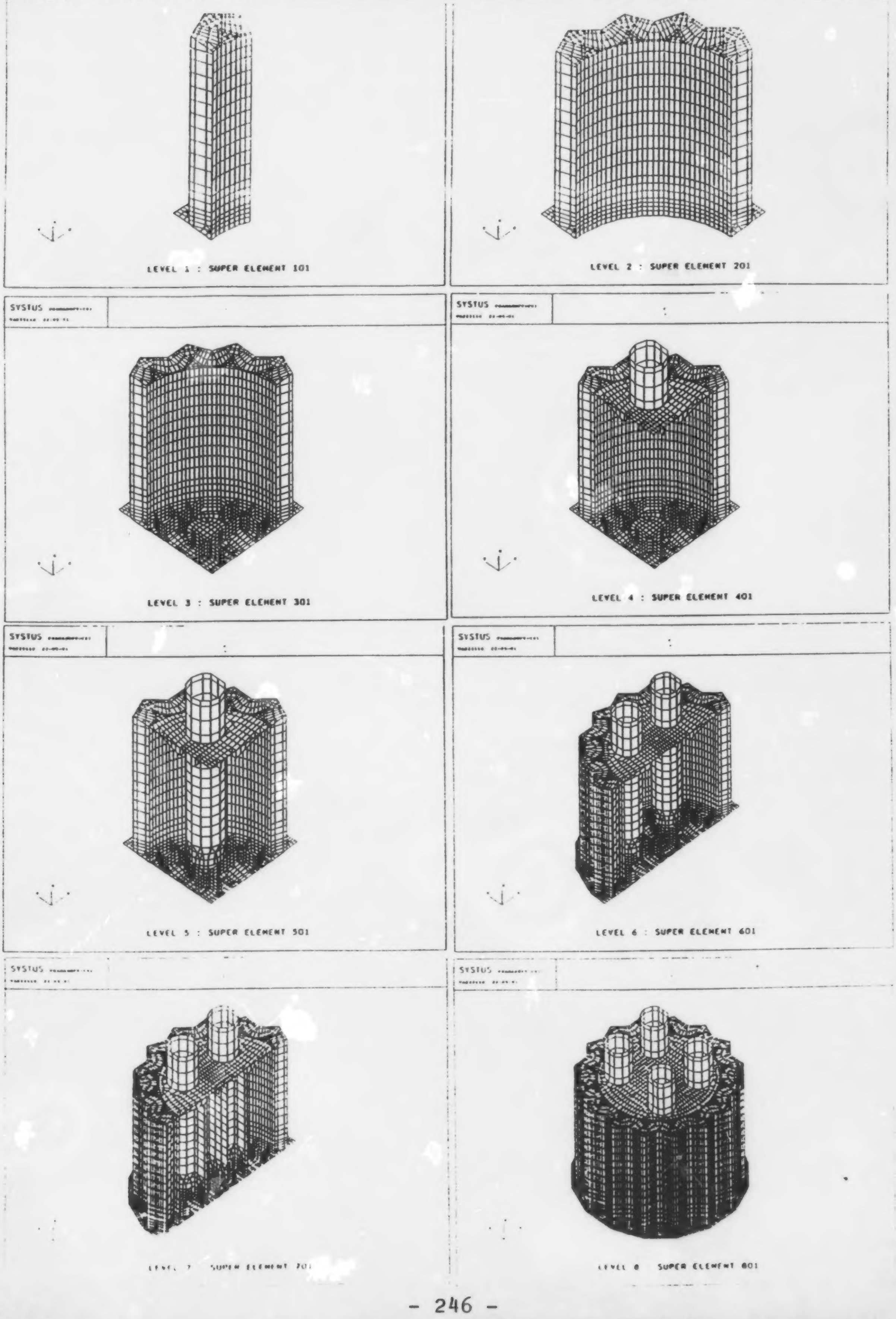


FIGURE N° 12

FIG. A6.1B


SYSTUS
SYSTUS
SYSTUS
SYSTUS
SYSTUS
SYSTUS
SYSTUS
SYSTUS

LEVEL 1 : SUPER ELEMENT 101

LEVEL 2 : SUPER ELEMENT 201

LEVEL 3 : SUPER ELEMENT 301

LEVEL 4 : SUPER ELEMENT 401

LEVEL 5 : SUPER ELEMENT 501

LEVEL 6 : SUPER ELEMENT 601

LEVEL 7 : SUPER ELEMENT 701

LEVEL 8 : SUPER ELEMENT 801

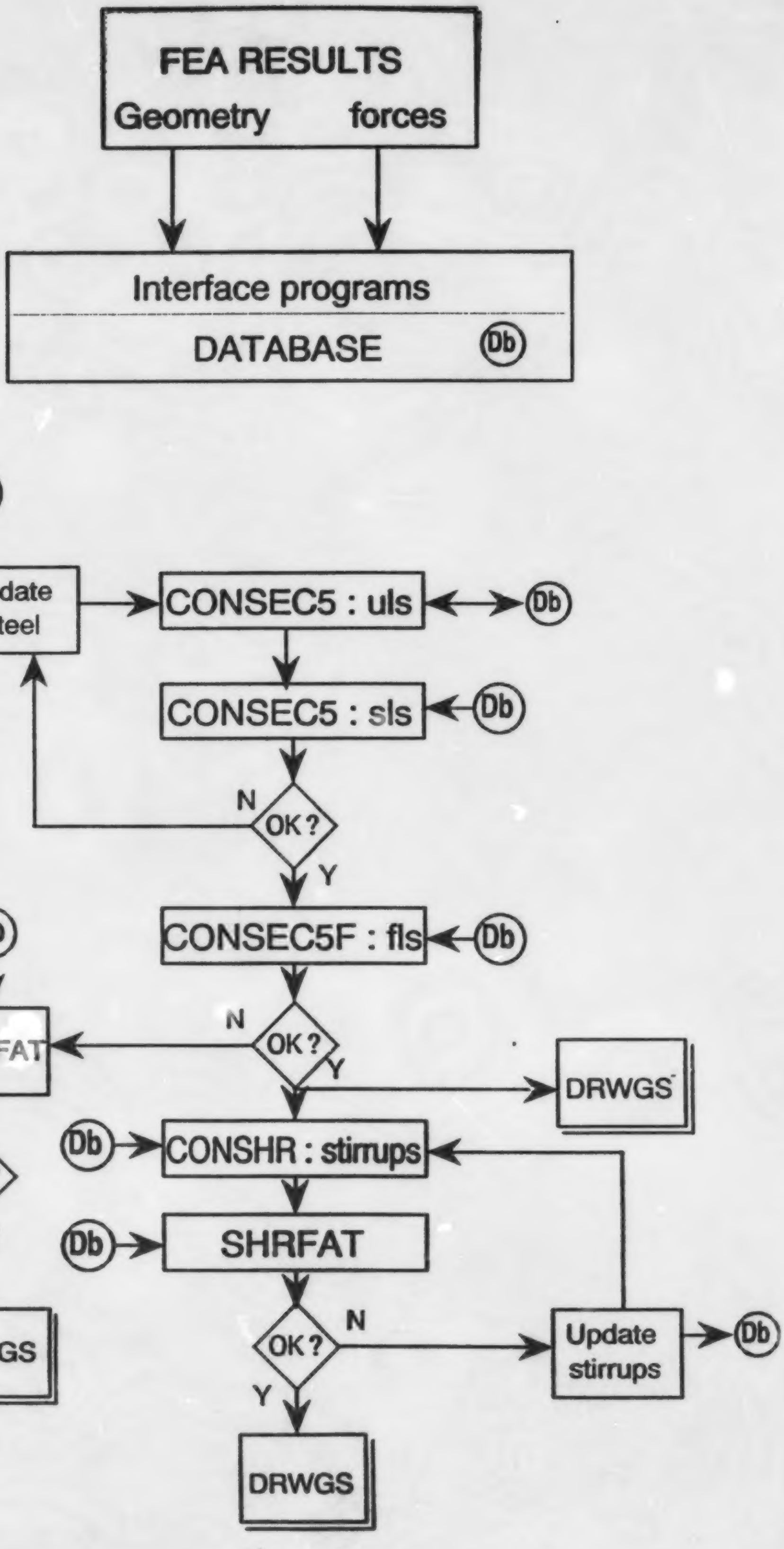

FEA RESULTS
Geometry
forces
Interface programs
DATABASE
Db
Db
Update steel
CONSEC5 : uls
Db
CONSEC5 : sls
Db
N
OK ?
Y
CONSEC5F : fls
Db
Db
CONFAT
N
OK ?
Y
DRWGS
Db
CONSHR : stirrups
N
OK ?
Y
Db
SHRFAT
OK ?
N
Update stirrups
Db
DRWGS
Y
DRWGS

FIGURE N°14

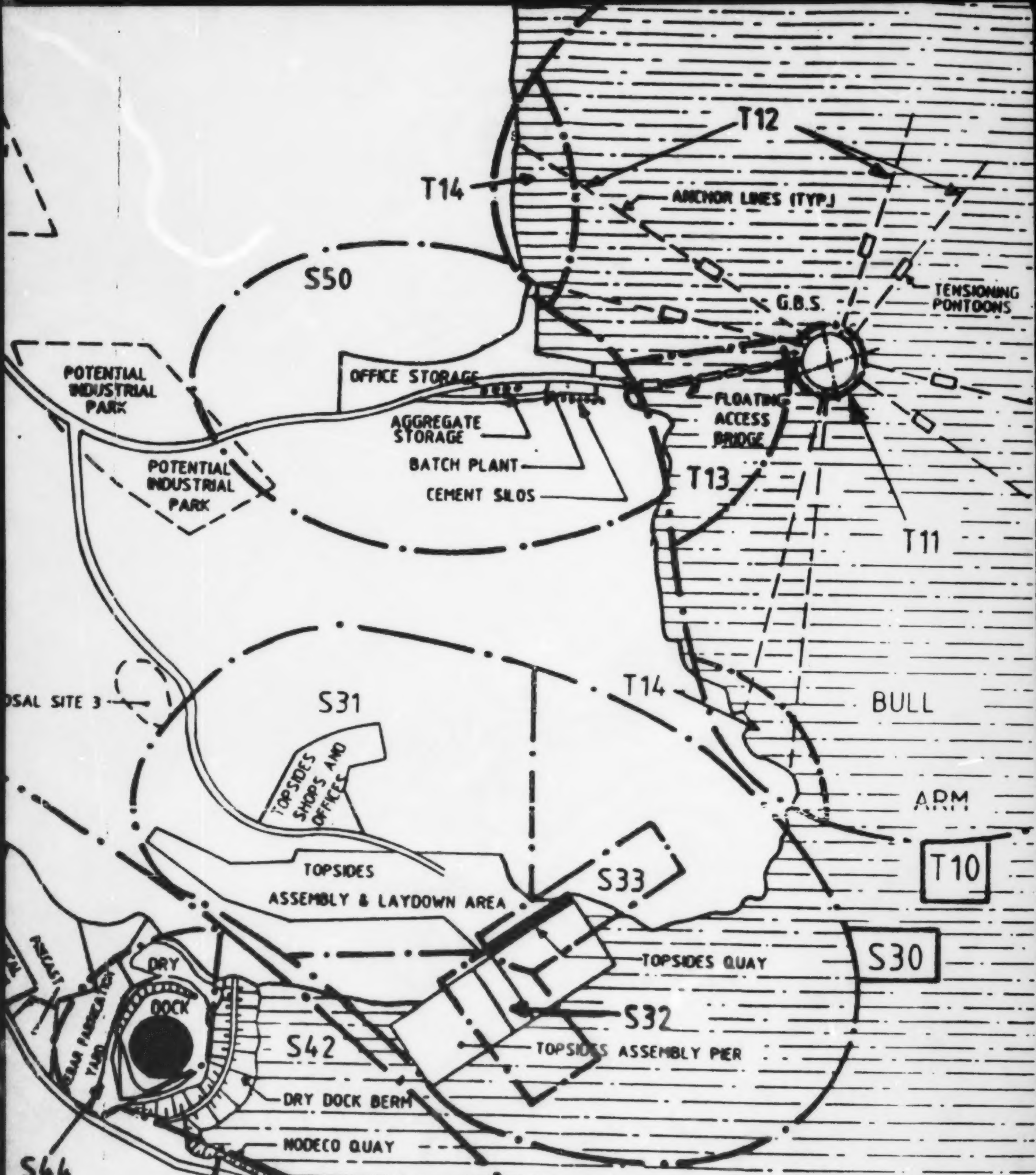
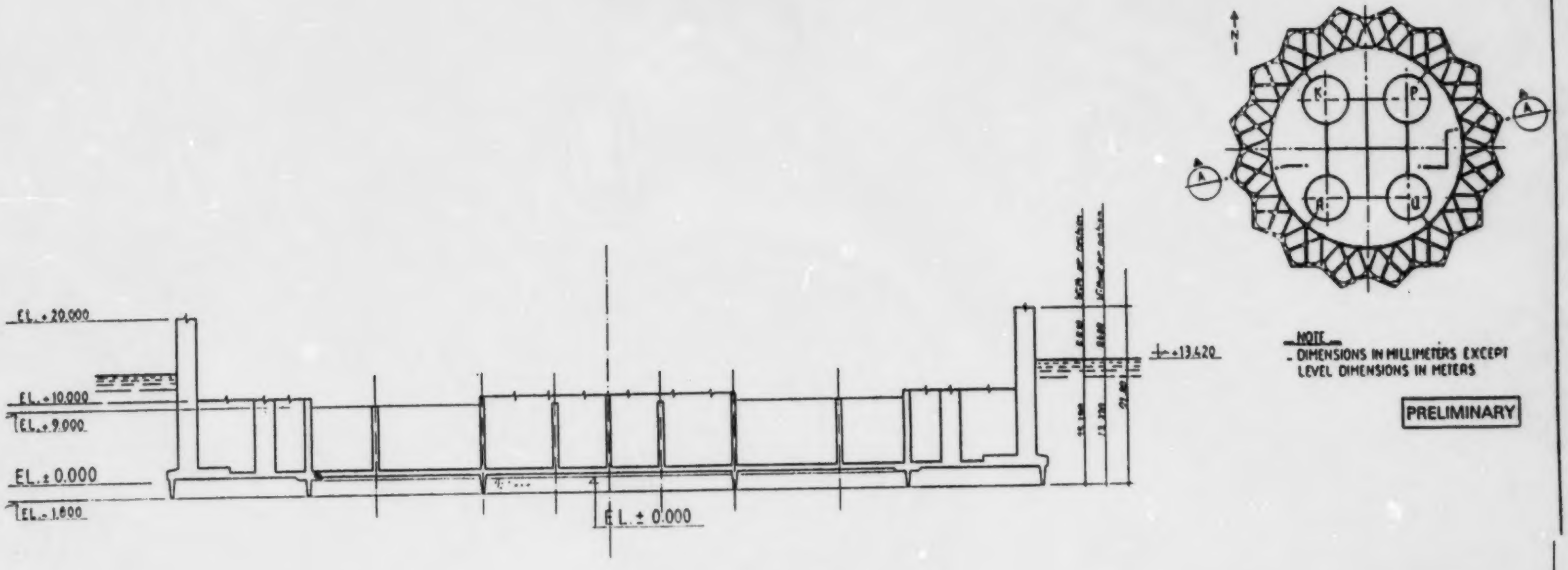

T12
T14
ANCHOR LINES (TYP.)
S50
G.B.S.
TENSIONING PONTOONS
POTENTIAL INDUSTRIAL PARK
OFFICE STORAGE
AGGREGATE STORAGE
FLOATING ACCESS BRIDGE
POTENTIAL INDUSTRIAL PARK
BATCH PLANT
CEMENT SILOS
T13
T11
T14
OSAL SITE 3
S31
BULL
TOPSIDES SHOPS AND OFFICES
ARM
T10
TOPSIDES ASSEMBLY & LAYDOWN AREA
S33
PRECAST
DRY DOCK
S30
TOPSIDES QUAY
REBAR FABRICATION YARD
S32
S42
TOPSIDES ASSEMBLY PIER
DRY DOCK BERM
NODECO QUAY
S44
S43
S40

FIGURE N°15



EL. + 20.000
EL. + 10.000
EL. + 9.000
EL. ± 0.000
EL. - 1.800
EL. ± 0.000
+ 13.420
N
K
P
R
U
A
A
NOTE
- DIMENSIONS IN MILLIMETERS EXCEPT
LEVEL DIMENSIONS IN METERS
PRELIMINARY

SECTION A.A.

FIGURE N°16

SPEAKER : ***STEVEN M. MILLAN***

COMPANY : ***CENTRE FOR COLD OCEAN RESOURCES ENGINEERING - C-CORE***

LOCATION: ***ST. JOHN'S, NEWFOUNDLAND***

TOPIC : ***PETROLEUM POTENTIAL OF THE SEDIMENTARY BASINS OFFSHORE NEWFOUNDLAND: A FRAMEWORK FOR DEVELOPMENT TO THE YEAR 2010***

BIOGRAPHY: *Steve Millan is a Geologist with some 30 years experience in oil exploration in Canada and worldwide. He is currently Associate Director of Memorial's Centre for Cold Ocean Resources Engineering. He was formerly Petro-Canada's Vice President for International and Frontier Exploration with responsibilities which included offshore Newfoundland and Labrador. He was the leader of the exploration group which discovered the Terra Nova Field.*

NOIA CONFERENCE '91

OFFSHORE NEWFOUNDLAND: THE BIRTH OF AN INDUSTRY

SESSION III: BEYOND HIBERNIA

Petroleum Potential of the Sedimentary Basins Offshore Newfoundland: A Framework for Development to the Year 2010

S.M. Millan*, A.E. Calverley**, A.J. Tankard**

*Centre for Cold Ocean Resources Engineering (C-CORE),
Memorial University of Newfoundland

**Petro-Canada Resources, Calgary, Alberta

Petroleum Potential of the Sedimentary Basins Offshore Newfoundland: A Framework for Development to the Year 2010

S.M. Millan, A.E. Calverley, A.J. Tankard

This presentation represents a change in pace from earlier sessions which dealt with specific technical topics pertaining to the Hibernia development project. In contrast, this presentation takes a general 20 year view into the future at the broad context within which the industry will develop.

The theme of this conference is "Offshore Newfoundland: The Birth of an Industry", while the title of this session of the conference is "Beyond Hibernia" ie. what the future might hold for the industry in the future. In addressing this theme, certain questions arise and form a general backdrop to this presentation. They are:

- Is this, as the conference title suggests "The Birth of an Industry" or are we simply at the start of a single, large project?
- What is a likely size and timing of this industry? Is it, for example, a new North Sea as we perceived it might be earlier in the exploration cycle?
- What are the main external factors which will influence the industry over the next 20 years?

and lastly

- What are the internal factors (over which we have some influence) and what can we do to optimize them?

The Hibernia mega-project is finally underway, signalling the start of a new phase in an extraordinary 25 year effort to discover and develop petroleum in this new frontier area offshore Newfoundland and Labrador. Six years of construction on this project will be followed by the production of more than 500 million barrels of oil over a period of almost 18 years. Besides Hibernia, other potentially commercial discoveries have been made, the most promising of which is the Terra Nova field operated by Petro-Canada.

My co-authors and I are all explorationists who have plied our trade for many years and in many parts of the world. We were all members of Petro-Canada's extraordinary exploration campaign on Canada's eastern offshore in the early to mid 1980's which tested most of the then recognized play types and produced a plethora of discoveries including Terra Nova which is the most likely candidate for development following Hibernia. As explorationists, we may perhaps be forgiven for starting this overview with a brief account of the geological and petroleum endowment factors of the region. In this, our remarks are focussed on the Grand Banks as, in our opinion, developments here are much more likely to happen in our 20 year time frame than either offshore Labrador or the very deep water of the continental slope. The petroleum endowment of the Grand Banks area and especially the Jeanne D'Arc basin, is the foundation upon which an industry will be built.

The continental shelf which extends 450 km seaward of Newfoundland has been intensely explored for hydrocarbons over the past 25 years, resulting in acquisition of 500,000 km of reflection seismic data and the drilling of more than 100 wells. Initially this exploration focussed on salt piercement structures in the relatively shallow water of the southern Grand Banks. This phase of exploration in the early 1970's established the presence of reservoir rock and oil but yielded no major discoveries. In May 1979, Hibernia P-15 was spudded on a large fault-bounded roll-over structure, and encountered substantial pay zones in Upper Jurassic and Lower Cretaceous reservoirs. Success followed success with significant discoveries in the Hebron-Ben Nevis complex, and at the South Tempest, Nautilus, Terra Nova, and Whiterose structures. These hydrocarbon accumulations are structurally trapped in mid-Mesozoic synrift sandstones in the Jeanne D'Arc basin.

Geophysical and geological studies show that the extensional basins underlying the Newfoundland continental shelf formed on a basement of late Precambrian and Palaeozoic accretionary terrains. In Mesozoic time, several episodes of rifting associated with the opening Atlantic ocean characterized the tectonic evolution of this area. However, the dominant period of rifting and basin formation was late Callovian to Aptian. Extension was accommodated by seaward-dipping listric and planar faults, and a suite of orthogonal transfer faults. The larger-scale transfer faults or accommodation zones separate regions with different structural styles and timing. Seismic structure mapping suggests a three-fold subdivision of the region:

1. Basins of the southern Grand Banks consist of numerous depocentres that subsided along strike-slip and normal faults. These pull-apart basins are seldom deeper than 8 km. They are characterized by large amounts of salt, diapirism, and deep erosion of the mid-Mesozoic section.

2. Dip-slip processes dominated the central Grand Banks, forming a suite of deep basins. The largest of these is the Jeanne D'Arc basin covering 10,000 km^2 and containing a post-Palaeozoic succession up to 17 km thick

3. North of the Grand Banks is a 450 km wide tract of rift basins that are collectively referred to as Orphan basin. These basins measure 30-50 km across and have up to 5 km of structural relief. Orphan basin is characterized by deep water (up to 2500 m), a very thick (4 km) post-rift terrace wedge, and small basin size.

At the present time, exploration mapping recognizes at least 25 basins beneath the Newfoundland shelf. However, most of the seismic and well information is concentrated in only three of these basins: Whale, South Whale and the Jeanne D'Arc and in the past decade most exploration activity has focussed on the Jeanne D'Arc basin. As a result, our knowledge of the area is not uniformly developed, nor is it by any means complete.

An assessment of the hydrocarbon of the Jeanne D'Arc Basin has recently been published by the Geological Survey of Canada and the Canada-Newfoundland Offshore Petroleum Board (Open File Report 2150). The purpose of the assessment was to determine the total quantity of oil that could be expected to exist in the

Jeanne D'Arc Basin. This quantity includes both what has already been found plus an undiscovered component, (potential), that can be inferred to exist based on current understanding of the geology of the basin.

No economic analysis was undertaken in the GSC report and the petroleum resources were expressed as *technically recoverable*, in contrast to in place values. The expression *technically recoverable*, means the quantity of hydrocarbons that can be produced by both primary and normal secondary recovery (ie. pressure maintenance) techniques, but excluding more exotic enhanced recovery methods.

For structural plays the resource endowment was expressed in terms of three arbitrarily selected size classes: ie. the number of pools and quantity of oil expected to exist in size classes greater than 100 million barrels, between 25 and 100 million barrels, and less than 25 million barrels. Estimates for stratigraphic plays were made as a percentage of total basin endowment, based on informed geological opinion. On this basis some 15 percent of the resources are expected to be contained in stratigraphic traps.

At a 50% confidence level, the GSC estimates that there is a 75% chance of a resource of at least 3.3 billion barrels and a 25% chance that the total exceeds 5.3 billion barrels. The average expectation (50% chance) is a resource of some 4.7 billion barrels. The GSC figures discriminate between that portion of the total endowment that has currently been discovered (1.5 billion barrels at a median value) and the remaining potential of 3.2 billion barrels at a median value. In total, 21 oil pools have been discovered in 14 fields.

The main focus of exploration to date has been the structural plays with endowment values ranging from 3.0 to 4.3 billion barrels. These structural plays are expected to continue to be the main exploration focus for the near future and examination of the GSC's field size distribution for these plays affords a measure of the continued interest that this basin will have.

For the structural plays, the GSC report shows a highly concentrated oil resource with more than 40% of the total oil predicted to occur in only 7 pools, each greater than 100 million barrels in size and 5 of which have already been discovered. The next size class, which includes pools between 25 and 100 million barrels is estimated to contain about 1 billion barrels located in 23 pools, 3 of which have already been found.

The GSC report concludes that the remaining potential in the structural fields, averaging about 3.0 billion barrels, and especially that part predicted to occur in 2 pools greater than 100 million barrels and in 20 pools greater than 25 million barrels, is sufficient to expect continued exploration in the basin.

We agree with this conclusion and suggest that the GSC figures are probably conservative in the sense that they are based on current knowledge and do not account for the "upside" opportunities presented by new exploration concepts or technologies.

One thing is clear, however, that conditions have been correct over geological time to generate a significant quantity of hydrocarbons on the Grand Banks. These conditions include rich source rock, generation, migration, reservoir rocks, trapping mechanisms and hydrocarbon preservation - all coming together to form a very large accumulation such as Hibernia. In exploration there is a saying that "you seldom see a lonesome oilfield" and it would be surprising indeed if what we see and know at present is all that there will be offshore Newfoundland in the future. The fact that companies continue to explore today under current adverse financial and economic conditions indicates their strong belief that there are more significant discoveries to be made.

Exploration concepts will continue to evolve as:

- new ideas are introduced from the international body of exploration knowledge;
- detailed information is generated from development drilling and reservoir performance at Hibernia and possibly Terra Nova;
- improving exploration data acquisition, processing, analysis modelling and display tools are focussed on more detailed basin definition and delineation as well as exploration play definition involving unique unconformity-bounded sequences that encapsulate a broad spectrum of stratigraphic and structural traps;
- improved knowledge of the deep crustal structure and fundamental basin architecture derived from research projects.

An example of how rapidly exploration technology is evolving is provided by 3-D seismic - a most powerful tool for a detailed understanding of subsurface geology. Since the existing Hibernia 3-D data set was acquired in 1980 and 1981, the survey ships now tow multiple streamers and multiple sources which makes it possible to collect five times more subsurface data per kilometre of ship track today compared with ten years ago. In addition, positioning accuracy has improved from ± 20 m to ± 10 m and lastly, the increased spacial sampling rate has improved the horizontal resolution of the survey from more than 75 m to 25 m or less.

Coupled with the improvements in data acquisition are improvements in processing technology - both hardware and software. This enables very large volumes of data to be processed without having to compromise the quality of the final product because of limitations in computer capacity. In addition, the interpretation of these large volumes of geophysical data is now feasible because of the availability of new interactive 3-D work stations.

The improved resolution of a new 3-D survey in the Hibernia area would, for example, permit the imaging of faults that could not be seen on the old data and more precisely define the throw and heave on known faults. Improved data will allow a more accurate estimation of pay thicknesses, reservoir depths and the horizontal position of faults, thus leading to an improved development drilling plan and potentially, increased reserves. The currently accepted recoverable figure for Hibernia may well be seen in the future to be extremely conservative.

In order to get an idea of the relative size of the Newfoundland resource compared, say, with the North Sea, it is preferable to deal with proven recoverable resources numbers rather than the resource endowment figures given above. In round numbers the proven recoverable resources at Hibernia are some 660 million barrels and approximately 400 million at Hibernia[1]. Over the next decade these two fields will most probably be developed, while in the decade following the next, some two to four field developments are possible with additional resources of 500 million barrels or more.

Thus, for scoping purposes, the industry will be built over the next 20 years on 4 to 6 developments containing some 1.6 billion barrels recoverable. In contrast, the proven resources of the U.K. and Norwegian sectors of the North Sea are some 3.8 and 11.6 billion barrels respectively (BP Statistical Review, June 1990) for a total of 15.4 billion barrels. The Newfoundland industry will therefore be built around a reserve base that is a little more than one tenth the size of that in the U.K. and Norwegian sectors. The industry in Newfoundland, therefore, can be expected to be less intensive and less continuous than that which developed in the North Sea.

In viewing how the industry offshore Newfoundland may develop, it is worth stating an obvious, but often forgotten, fact - that events here are strongly driven by external factors. In this regard, the following broad considerations are noted because of their key influence on the environment of development:

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[1] from "Hydrocarbon Discoveries Offshore Newfoundland and Labrador", Oct. 1990; Dept. of Mines & Energy, Gov't. of Newfoundland and Labrador.

__Firstly__: Petroleum, and the petroleum industry, are world ranging with petroleum being the most internationally traded of all commodities. As a consequence, companies are usually faced with a variety of investment options worldwide at any particular time. The projects that get funded are those which promise the best returns with acceptable risks.

Developments offshore Newfoundland, therefore, do not occur in isolation but rather within a global competitive context.

__Secondly__: While patterns of use and the energy intensity of industry changed in the 1970's and 1980's, conventional petroleum remains the dominant source of energy and substitution by other forms of energy has taken place much more slowly than was forecast to happen during the 1970's. At that time relatively rapid substitution by alternate forms of energy was forecast to have occurred, driven by scarcity of conventional petroleum and rapidly escalating price.

This has not happened and the petroleum industry is expected to remain a powerful economic element over the 20 year planning period although the industry continues to undergo fundamental structural change.

__Thirdly__: Obviously, but worth repeating, petroleum is a non-renewable resource - once it is produced and used, it is gone. For a producing company this means a constant need to, at least, replace produced reserves or go out of business.

Recently, especially in North America, it has been, in theory at least, possible to buy known reserves in the ground cheaper than to discover new resources through exploration. Pursuit of this short term business strategy has seen a reshuffling of known petroleum reserves, the disappearance of significant exploration and production companies, the burdening of many surviving corporations with excessive debt and the destruction of a significant part of our exploration capabilities - both human and infra-structure.

Within this context of a need to discover and develop new sources and a diminished capacity to do this, the potential of offshore Newfoundland assumes additional value.

Fourthly: The Middle East overwhelmingly dominates the world's known reserves and this position continues to grow stronger with the drawdown of non-Mid East reserves and substantial reserves additions being made in the Middle East over the past 3 years where proven reserves are in the order of 660 billion barrels (BP statistical Review, June 1990). In contrast, international exploration outside of the Middle East has not yielded any major new reserves. The recent destruction of reserves in Kuwait has not been taken into account but will not substantially alter the dominance of Middle East reserves and the increasing dependency of the world on suppliers of this economically vital commodity from one geographic area.

In the face of this potential monopolistic position, non-Middle East /non OPEC reserves, such as those offshore Newfoundland, are important supply alternatives for price stability and national security.

Lastly: Environmental concerns pertaining to atmospheric pollution and greenhouse gasses will depress oil demand and place a premium on natural gas as a more environmentally acceptable fuel. This has important implications for the value and disposition of both associated and non-associated gas in the East Coast offshore.

Strict conservation and utilization of gas produced in association with oil at Hibernia and other offshore fields will be required by regulating bodies while known major gas discoveries offshore Nova Scotia and perhaps southern Labrador may be expected to regain development significance within the next 20 years.

These considerations illustrate the futility of trying to accurately forecast the development of the industry over the next 20 years or to attempt to isolate Newfoundland from the global trends of the industry. Of more promise would be to take the strategic approach of defining our ultimate goals then taking the reasonable steps necessary to achieve those goals.

A reasonable overall goal may be to achieve an industry of substantial size which has the following attributes:

- sustainability
- growth
- stability
- profitability
- diversity
- quality

What opportunities, then, do we have to achieve the overall industrial development goal and what actions shall we take?

Firstly, there is the Hibernia construction project and the development and production activity which will take place throughout the 20 year focus of this paper. While nothing is 100% certain, it would be extremely unlikely not to see this project executed more or less as currently planned.

The construction project has two characteristics which are particularly important from an industrial development viewpoint:

1) it is finite in time - the scheduled end is 1996; and
2) it will bring together the top people and best technologies in Newfoundland for a concentrated period.

If the industry is to have a life beyond Hibernia, those companies associated with construction must identify as soon as possible their next projects - wherever in the world they might be. Projects on the Nova Scotian shelf or cold regions of North America, Norway and the USSR may be special targets because of technical similarities.

Industry players should also be alert to the application of skills and technologies to industries outside of petroleum. At Hibernia, for example, project management, communications, cost-control, QA/QC, finance, etc. will all be state-of-the-art and transferrable to applications outside of petroleum. This represents a large economic opportunity for Newfoundland based firms.

The various aspects of the production phase present an excellent employment and industrial opportunity for the longer term.

Resulting from the development of Hibernia will be the development of human resources and infrastructure of particular relevance to the development of a subsequent field. Hibernia will also be the pathfinder development in a new operating environment which will have the effect of reducing certain project risks for subsequent projects. Coupled with innovation and technology development, the increased availability of infrastructure and continuing reduction of project risk through experience, all will have the effect of improving the economics of developments following Hibernia.

Secondly, there is the Terra Nova discovery which is actively being considered for development by its owners under the operatorship of Petro-Canada. Within the 20 year planning period, it is considered highly likely that Terra Nova will be developed. From a planning viewpoint, the ideal timing for the Terra Nova start-up would be when Hibernia development activities are beginning to decline.

Development of other currently known discoveries such as Whiterose or Hebron is less certain and probably requires fairly significant improvements in the economics and/or reserves in these fields before development will move ahead. For scoping purposes, as discussed earlier, it is probably not unreasonable to assume that the first decade of the planning period will see Hibernia and Terra Nova developed while the next decade may see two to four further developments drawn from currently known discoveries plus discoveries yet to be made.

Thirdly, there are industrial opportunities associated with ongoing exploration and delineation work. On the exploration side, drilling will probably average one well per year while there is probably support for one geophysical ship per summer for the next five years to ten years. This activity will not be evenly distributed in time but will probably be spasmodic. Additional drilling and seismic work may be generated in the second decade of the plan period by delineation of the two developments which are assumed to occur in this period.

In summary, therefore, a likely industrial development scenario over the next 20 years may be based on opportunities arising from Hibernia, Terra Nova and two to four other assumed developments, plus a modest exploration and delineation program. For reasonable continuity and growth, however, the Newfoundland industry will have to aggressively pursue business both in other geographical areas and in other industries. Thus, parallel business strategies are required: one inward looking and the other outwardly focussed.

Inwardly, we must do our best on the following:

- demonstrate that Newfoundland is a good place to do business with excellent co-operation between all sectors of the society: Industry, Labour, Government and the research and training institutions;
  - achieve exceptional performance on Hibernia;
  - ensure that the inflow of technology associated with Hibernia really happens and that the new technology is enhanced and directed to new developments and new industries;
  - continue to develop technologies which are unique to cold oceans as a basis of removing disincentives to developments in Newfoundland and as a viable technology export commodity.

Externally, we must formerly set ourselves a goal to be an integral part of the international oil business and to secure international work individually or in consortia based on our know how and competitiveness.

On behalf of my co-authors, I would like to thank NOIA for inviting us to make this presentation and I would like to acknowledge the contribution made by Allin Folinsbee of Petro-Canada during the preparation of this paper.

SPEAKER : ***IAIN K. SINCLAIR***

COMPANY : ***CANADA-NEWFOUNDLAND OFFSHORE PETROLEUM BOARD***

LOCATION: ***ST. JOHN'S, NEWFOUNDLAND***

TOPIC : ***EXPLORATION POTENTIAL OF OFFSHORE NEWFOUNDLAND & LABRADOR OUTSIDE THE JEANNE D'ARC BASIN***

BIOGRAPHY: *Iain Sinclair worked for Mobil Oil Canada for five years, mainly in Grand Banks exploration, prior to joining the Canada-Newfoundland Offshore Petroleum Board in 1986. In his position of Senior Geologist, Iain has studied the relationships between tectonism, sedimentation, and hydrocarbon prospectivity for both the Mesozoic Jeanne D'arc Basin off Eastern Newfoundland and the Lower Paleozoic Anticosti Basin off the Province's West Coast.*

EXPLORATION POTENTIAL OF OFFSHORE NEWFOUNDLAND & LABRADOR, OUTSIDE THE JEANNE D'ARC BASIN

#1 Ladies and Gentlemen:

The Hibernia Field of the Jeanne d'Arc Basin has been the focus of much media attention for the past dozen years, as well as the main topic of this year's NOIA Conference. I thought I might give you a break.

The area under the Canada-Newfoundland Offshore Petroleum Board's jurisdiction covers roughly 1.66 million square kilometres of which the Jeanne d'Arc Basin covers only about one percent. This presentation will mainly address the hydrocarbon potential of the other 99 percent of the offshore area with a brief review of the exploration histories and the known geology.

The offshore can be divided into 14 sedimentary basins of which 10 are relatively young Mesozoic basins highlighted in yellow, and 4 are older Paleozoic basins shown in green. I'll review the yellow Mesozoic basins first.

#2 Let's begin with the Jeanne d'Arc Basin just to establish what we would call a successful area. This diagram charts the kilometres of seismic data shot each year. Seismic surveying is the collection of reflected sound waves which, after computer processing, provide an image of the general underground structure and potential hydrocarbon traps. The first industry survey which targeted the Jeanne d'Arc Basin was shot in 1966, five years prior to drilling of the first well, Murre G-67, in 1971. Geophysical surveying generally precedes drilling and, therefore, the acquisition of over 16,000 kilometres of seismic data in 1990 bodes well for an upcoming increase in drilling activity. That increase is likely underway right now with at least two wells anticipated for drilling this year.

#3 This chart shows the number of wells spudded each year in green with the metres drilled per year in purple. A few of the wells which could be considered milestones are shaded black. The first wells drilled in the Jeanne d'Arc Basin provided early indications of the significant discoveries to come. Adolphus 2K-41, only the fourth well drilled in the basin, produced small amounts of medium gravity oil to surface. The fifth well, Egret K-36, penetrated significant thicknesses of both reservoir quality sandstones and highly organic-rich rocks. The sandstones demonstrated the presence of sediments capable of storing and producing significant reserves of oil and gas which could have been sourced from the underlying organic-rich rocks. These are crucial components for the prospectivity of any sedimentary basin. After a drilling hiatus of four years, the eleventh well drilled was the now famous, or infamous, Hibernia P-15. This well was operated by Chevron through a farm-in agreement on Mobil Oil's acreage. The search for similar traps in faulted Upper Jurassic and Lower Cretaceous sandstones dominated exploration for the next five to ten years yielding additional major discoveries such as Terra Nova.

The less well known Mara M-54 discovery well unexpectedly encountered a small oil pool in relatively young, unstructured Lower Tertiary age sediments. This Tertiary horizon now is expected to play a significant role in future exploration efforts within the Jeanne d'Arc Basin and perhaps beyond.

#4 We'll now move east 100 kilometres or so to the Flemish Pass Basin, an area with a number of characteristics in common with the Jeanne d'Arc Basin, though also displaying important differences. This map, from Creany and Allison of Esso, shows one crucial feature of the area, that being the presence of mature, organic-rich, oil-prone source rocks highlighted in green, over much of the Flemish Pass Basin. However, the lack of this unit in the Kyle well results in uncertainty as to the extent of source rocks in the southern portion of the basin.

Next I will show a geologic cross-section through the Lancaster and Gabriel wells.

#5 This diagram illustrates both positive and negative features of the Flemish Pass Basin. On the positive side, the Gabriel well encountered thick, porous reservoir quality sandstones of Early Cretaceous age in this structural inversion feature. These sandstones appear to be very similar to the highly productive Hibernia Formation of the Hibernia Field. Also, traces of migrated oil were detected in sandstones from the Gabriel well. Finally, the Jurassic oil-prone source rocks, shown on the previous map, were penetrated by Baccalieu I-78 as well as the Lancaster well. The Gabriel, Lancaster and Baccalieu wells, therefore, indicate the presence of the same three elements recognized in the Jeanne d'Arc Basin prior to discovery of Hibernia, that is reservoir rocks, source rocks, and free or movable oil.

Given these very positive early results, why has drilling stopped in this area? One of the main factors is water depth which runs about 1000 metres over much of the basin, more than 10 times the water depth present over the Hibernia structure. This raises additional technical difficulties and costs for exploration and production.

#6 A second problem is ice. Ice arrives here early compared to the Jeanne d'Arc Basin area as the seafloor topography channels the Labrador current through the Flemish Pass area. As a result, the pack ice front curls around the Grand Banks at the 200 metre isobath shortening the drilling season. Also in waters deeper than 200 metres, iceberg size is not limited by grounding on the seabed, so that the maximum expected iceberg size is about 10 times that in the Hibernia area. A positive side to the same point, however, is the seafloor is not scoured by recent icebergs in such deep water so that seabed installations would not be at risk.

#7 This chart shows just how little drilling has occurred in the Flemish Pass Basin, that is, only four wells including the Lancaster well on the basin's western margin. The three wells penetrating the main graben fill sediments are, again, Gabriel, Baccalieu and Kyle.

#8 This chart shows seismic surveying of the Flemish Pass continued from 1970 to 1985 at low to moderate levels. The lack of seismic surveys over the last five years indicates drilling is unlikely to resume soon.

Oil price increases and technological advances in ice handling and deep water production systems over the next five to ten years may be sufficient to cause exploration to return to this highly prospective area.

One encouraging note is provided by Brazil's state oil company, Petrobraz, which is continuing to extend the frontiers of deep water technology in their push to develop Brazil's offshore Campos Basin. The oil and gas journal reports Petrobraz has let a contract to develop a tension leg platform capable of working in 1000 metres of water and producing 100,000 barrels per day of oil.

The existence of such a platform could greatly affect the outlook of oil companies on the attractiveness of the Flemish Pass Basin.

#9 (Same diagram as #1)
Let us now review the prospectivity of the southern Grand Banks area where industry's exploration of Newfoundland's offshore began. This area includes the South Whale, Whale, Horseshoe, and Carson/Bonnition Basins as well as the southern end of the Jeanne d'Arc Basin.

#10 Thousands of kilometres of seismic surveying over the south Grand Banks occurred nearly every year from 1964 to 1974, followed by a six-year lull. Surveying resumed during the 1981 to 1985 period, partially in response to frontier exploration funds made available through the National Energy Program.

#11 Wells were drilled in rapid succession during a four-year period beginning in

1971. Though no significant discoveries were made, two wells are of particular exploration interest. In 1971, Puffin B-90 drilled a very thick, Lower Cretaceous-age sandstone exhibiting excellent reservoir characteristics. The following year, Heron H-73 produced a very heavy oil illustrating, at least, the local presence of a hydrocarbon source rock within the area's sediments. The Narwhal F-99 well is of technical interest for holding Newfoundland's deep water record for drilling in just over 1.5 kilometres of water.

#12 This cross section through several south Grand Banks wells illustrates one very important point controlling the prospectivity of the area. The northeast portion contains highly distorted and deeply truncated Jurassic sediments, shown here in purple. As a result the Upper Jurassic interval, which contains hydrocarbon source rocks in the Jeanne d'Arc Basin to the north, is missing due to erosion in this area. Only in the South Whale Basin, as around the Puffin well, and in the northeast portion of the Carson/Bonnition Basin were upper Jurassic sediments protected from deep erosion by subsidence, that is sinking, during the latest Jurassic and Early Cretaceous times. Such areas also contain the thickest reservoir-quality sandstones in the yellow coloured Early Cretaceous horizon. As a result these two portions of the south Grand Banks have remaining hydrocarbon potential.

It will likely be some years, however, before explorationists will overlook the stigma of numerous disappointments from early wells and the lack of a demonstrated, though still plausible, hydrocarbon source rock.

#13 Let us now turn briefly to the East Newfoundland and Orphan Basins occurring over a large area of which little is known despite the drilling of six wells. First I will show a cross-section through three of those wells drilled on the SW margin of the basin.

#14 Here we see one of the area's extensional grabens flanked by basement highs coloured red. Most wells drilled to date have been located on the largest structural highs which, unfortunately, have been tilted basement blocks buried beneath mainly unstructured Upper Cretaceous and Tertiary sediments highlighted in blue. Little is known about the yellow graben fill sediments which have only been penetrated to any significant degree by Linnet E-63. A few sandstones encased in thick shales were encountered in this well, providing some indication of at least the presence of reservoir rocks within the graben fill. However, we have little data on which to base a prediction of the presence of source rocks within the grabens.

An additional problem, ignoring for the moment ice hazards and water depths, is the great thickness of Tertiary age sediments which have buried the grabens making seismic imaging of the graben fill marginal at best. As a result, an improvement in seismic acquisition and processing would be helpful in assessing the exploration risk of drilling targets within the grabens. Also, a few more occurrences of hydrocarbons in Tertiary age sediments of the Jeanne d'Arc Basin could result in the application of a similar play to the young sediments of the East Newfoundland and Orphan Basins.

#15 This chart shows two periods of intense seismic surveying of this northern Grand Banks area during the early 1970's and the early 1980's but

#16 limited drilling of mainly a single play type has not resulted in any successes. This offshore area could easily be classed as high risk for oil exploration so that it is unlikely we will see an early renewal of activity. However, with risk goes the possibility of reward and given the limitations of today's data set, portions of the East Newfoundland and Orphan Basins have the potential to hold major reserves of hydrocarbons.

#17 I cannot attempt to give the Labrador Shelf the attention that it deserves here, so I will limit myself to a very brief review. This chart shows offshore Labrador received intense geophysical scrutiny beginning in 1968 and ending in 1984. A short government survey was shot last year.

#18 25 wells were drilled resulting in 5 significant gas discoveries. The first gas pool was encountered by only the third well drilled, Bjarni H-81. The North Bjarni structure contains the largest discovered gas resources off Labrador estimated by the Board to contain 2.2 Tcf of gas at 50% probability. This discovery record would constitute a successful start to continuing exploration and possible production in many locations in the world. However, given the intense ice hazards, great distance from markets and the relatively low current price of gas, marketing of these resources is going to be very difficult. As a result, an early resumption of exploration activities or commissioning of a production system is unlikely in the near future.

Also the lack of a mature, oil-prone source rock within or below the main Lower Cretaceous reservoir sandstones results in low probability of abundant oil resources occurring off Labrador. The only oil encountered to date has been a minor flow of waxy oil from North Leif I-05. This oil has been interpreted to be from terrestrial, mainly gas-prone source rocks unlike the marine, oil-prone source rocks of the Jeanne d'Arc Basin.

#19 A very exciting frontier area known as the Anticosti Basin exists in the Gulf of St. Lawrence off Newfoundland's west coast. This area is quite "new" to exploration despite the presence of oil having been recognized onshore western

Newfoundland as early as 1812. The Anticosti Basin is the northernmost of a string of Paleozoic-age basins located mostly onshore and inboard of the Appalachian/Ouachita thrust front of eastern North America. The basins generally have long exploration and production histories but recent major discoveries in the U.S. such as the Wilburton Field in Oklahoma have identified a new prolific play in fractured Cambro-Ordovician-age dolomites. These discoveries have spurred interest in Newfoundland's west coast both onshore and off. In fact, five offshore Anticosti Basin parcels were awarded to four different companies in 1990. These companies have committed to spend nearly $5 million over a five year period. An additional offshore parcel is being offered for bids this year, while the province has called for industry to post lands onshore.

#20 Relatively little is known about the offshore structure given the paucity of seismic surveying over the years, though one short survey was shot in 1990 and further activity is planned for this summer.

#21 However, considerable information can be gleaned from study of the onshore portion of the basin. Structures such as the Ten Mile Lake Thrust fault and others of the Northern Peninsula and their interpreted offshore extensions provide highly prospective targets. Wells must be spudded within the next four and one-half years on each of the Gulf of St. Lawrence parcels let in 1990 to extend the life of the licences for an additional four years. This requirement, as well as the favourable geology, will likely assure drilling begins within 3 to 4 years.

#22 (Same diagram as #1)
There are at least three Late Devonian to Carboniferous-age basins located totally or partially within the waters surrounding the Island of Newfoundland. These are the St. Anthony, Bay St. George and Sydney Basins. The prospectivity of these basins is poorly defined by the limited available data. Only two offshore wells have been drilled in these three basins and the Carboniferous sandstones of the St. Anthony Basin were water-bearing in both the Verrazano and Hare Bay wells. Late Devonian and Carboniferous sediments penetrated by several south Grand Banks wells were also non-hydrocarbon-bearing. However, limited evidence for the presence of oil source rocks within these basins exists from the onshore portion of the Bay St. George Basin and from the totally land-locked Deer Lake Basin. Rock samples from the onshore portion of the Bay St. George Basin, collected by CNOPB staff in early June of this year, have been sent to the Institute for Sedimentary and Petroleum Geology in Calgary. That branch of the Geological Survey of Canada will analyze the samples to further test their potential as hydrocarbon source rocks. Also minor occurrences of oil and gas have been noted during

onshore drilling for gypsum over the Flat Bay anticline adjacent to St. Georges Bay. Also of relevance is the Carboniferous Stony Creek Field of New Brunswick which has been producing light gravity oil at low levels since its discovery in 1909. A number of Gulf of St. Lawrence wells have been drilled into Carboniferous sediments outside of Newfoundland waters but unfortunately only one has tested hydrocarbons, that being gas from East Point E-49 drilled between Prince Edward Island and Cape Breton.

#23 This chart shows only minor surveys were run over the Carboniferous basins in Newfoundland waters, and these surveys are rather old having been shot mainly in the 1969 to 1976 period. A concerted effort using modern techniques is required to lower the exploration risk associated with these prospective but relatively weakly surveyed and sampled sediments. The 1990 licensing of two offshore parcels in the Bay St. George Basin indicates renewed efforts to collect additional data will likely begin within two to four years.

#24 This photo caught two geologists of Newfoundland's Department of Mines and Energy and the Canada-Newfoundland Offshore Petroleum Board showing a keen interest in the hydrocarbon prospectivity of western Newfoundland despite some adverse climatic conditions. Also a group of industry geologists and geophysicists have just completed a field trip to western Newfoundland under the guidance of Memorial's Centre for Earth Resources Research. You can therefore be assured that Bull Arm is not the only site of oil industry activity in Newfoundland.

#25 Same as Diagram #1)
In summary, there is considerable potential to discover significant new reserves of oil and gas outside the Jeanne d'Arc Basin. The two such areas that are liable to see the earliest action are the Anticosti Basin and the Flemish Pass Basin. Companies have committed considerable sums for work offshore western Newfoundland and that exploration is already underway. The Flemish Pass Basin is highly prospective with the demonstrated existence of all the elements required for accumulation of major resources. As soon as technology and prices allow, this area will be the centre of renewed activity.

I hope this cursory review of the various offshore basins has provided some appreciation of the vast areas remaining to be explored and exploited off Newfoundland and Labrador.

DRILLING ACTIVITY
(Spuds)

Basin Name	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTALS
South Grand Banks	2					4	8	13	4												1	1				33
Jeanne d'Arc						1	3	2	3					1	5	5	3	5	12	9	4	4	7	1	1	66
Flemish Pass														1						1	2					4
East Hills/Orphan									1	1				1		1	1			1						6
St. Anthony											1			1												2
Labrador Shelf						1		2	1	5	2		3	3	5	2	1	2								27
Anticosti																										
St. George																										
Sydney																										
TOTALS	2	0	0	0	0	6	11	17	9	6	3	0	3	7	10	8	5	7	12	11	7	5	7	1	1	138

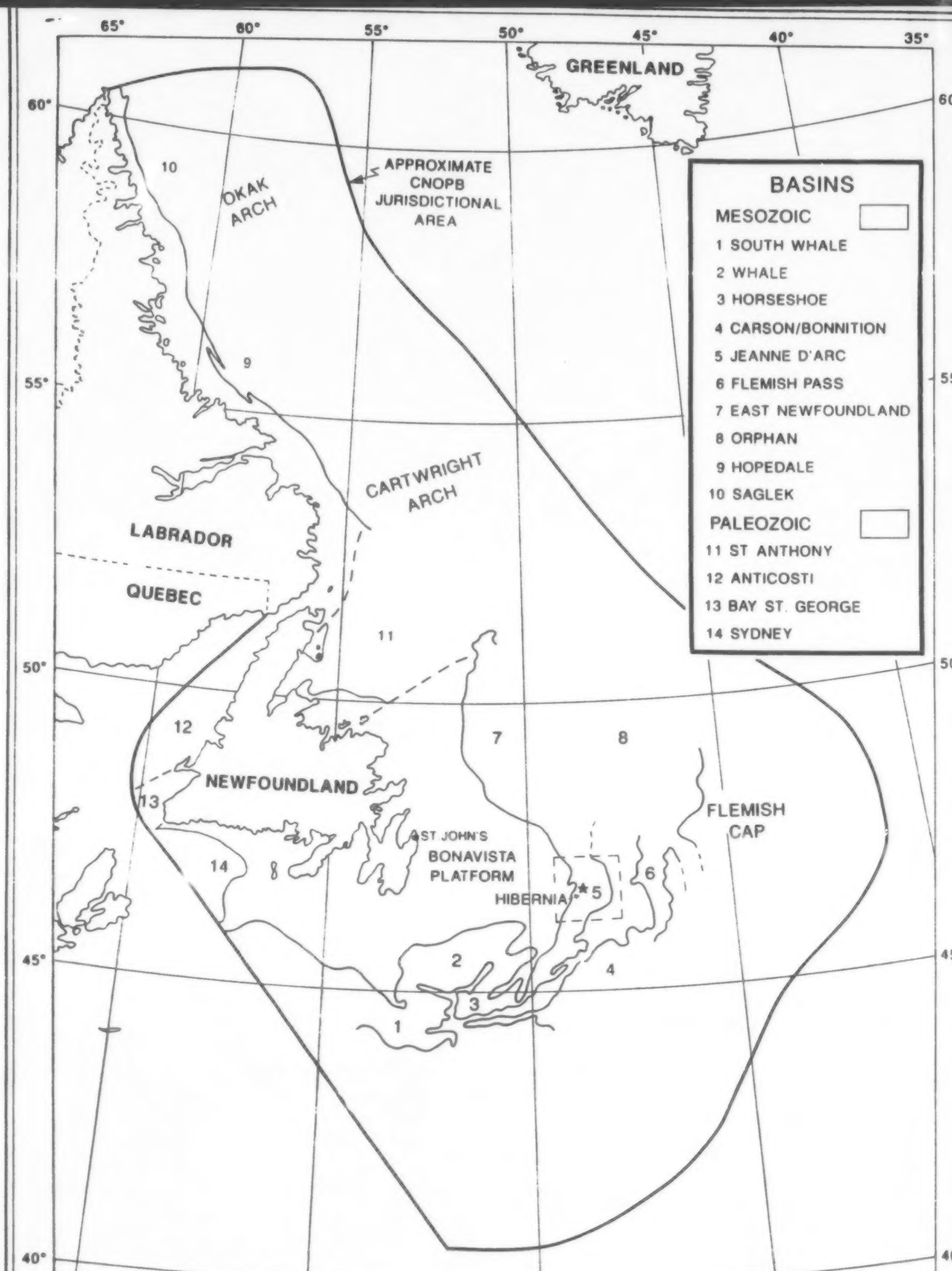
DRILLING ACTIVITY
(Metres)

Basin Name	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTALS
South Grand Banks	2873.6					11782.2	28970.6	34807	18310.7												4100.2	4866				105710.3
Jeanne d'Arc						3337.3	9988.5	8464.6	10427					4400.8	18847.3	33463.7	10995.2	20794.5	46605.1	36209.6	17484.2	12591	10667	5678.0	3898	257110.6
Flemish Pass														6171						6136	9901					22208
East Hills/Orphan									3085.1	4820.4				6109.1		5496.4	4680.2			4611						28802.2
St. Anthony											486.9			4674												5160.9
Labrador Shelf						1094.2		4383.7	2636	13066.1	6593.2		6741.4	8311	12214	8786	7596	3767								75188.6
Anticosti																										
St. George																										
Sydney																										
TOTALS	2873.6	0	0	0	0	16213.7	38959.1	47655.3	34458.8	17886.5	7080.1	0	6741.4	29665.9	31061.3	47746.1	23271.4	24561.5	46605.1	46956.6	31485.4	17457	10667	5678.0	3898	488893.1

SEISMIC ACTIVITY
(Kilometres)

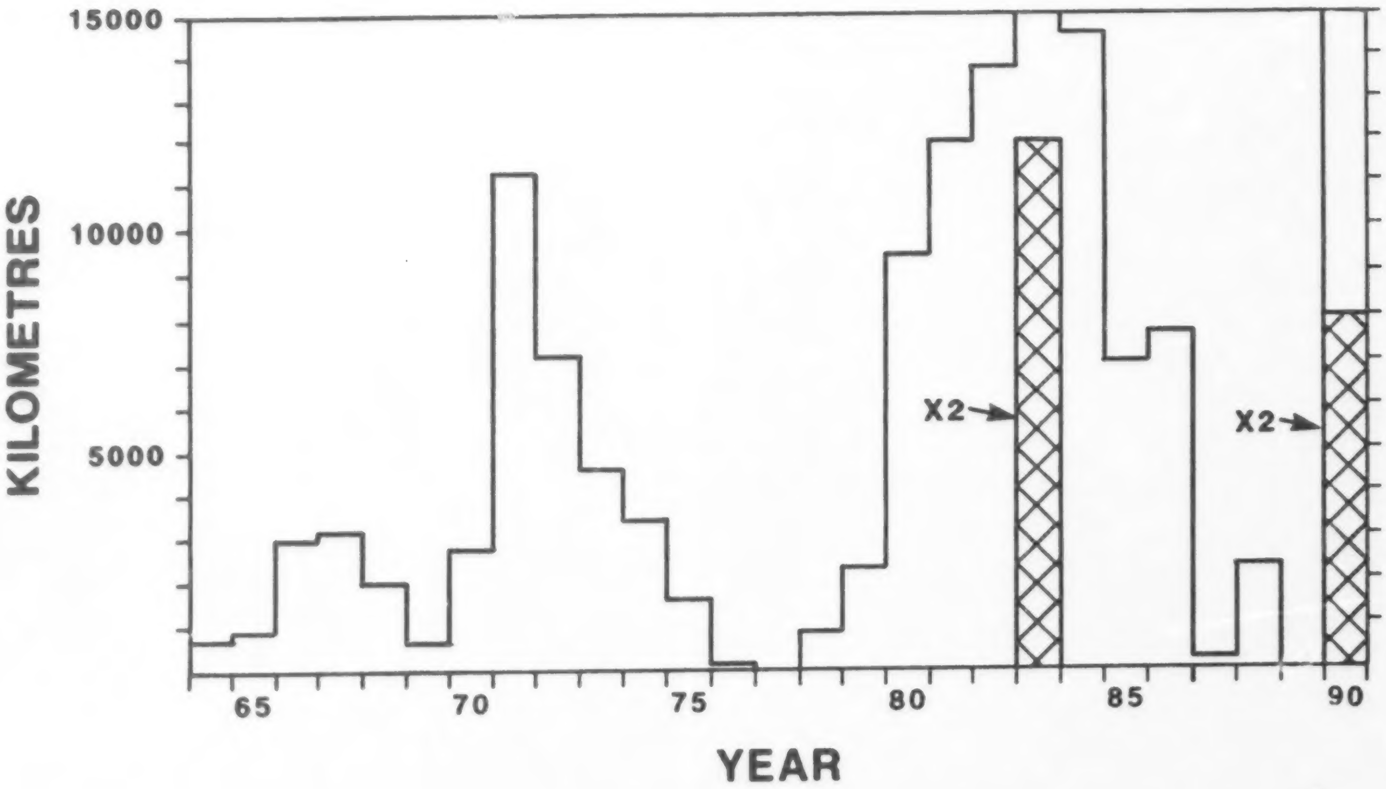
Basin Name	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	TOTALS
South Grand Banks	8414	[illegible]	480	8851	9134	1894	[illegible]	6837	[illegible]	7877	4182	788	880	618			384	6848	14088	11844	2788	6857		880				118[illegible]
Jeanne d'Arc	751	[illegible]	2047	3218	2181	[illegible]	[illegible]	11282	7880	4080	2480	1080	60		801	2108	8487	14848	12088	84880	14873	7043	7780	330	2484		16880	164730
Flemish Pass				39			[illegible]	[illegible]	1280	2048	1440	2847	[illegible]	1080	1480	1711	[illegible]	[illegible]	3080	5751	6477	1408						40840
East Nfld/Orphan						847		[illegible]	12082	10870	[illegible]	[illegible]	843	1089	140	780	[illegible]	[illegible]	14310	[illegible]	2488	870		380				[illegible]
St. Anthony					484	1080	448	[illegible]	3840	[illegible]	3875	1848	1128	387	385		84	273	73		318	385						18870
Labrador Shelf					[illegible]	[illegible]	[illegible]	11[illegible]	10331	[illegible]	[illegible]	[illegible]	8470	11180	[illegible]	[illegible]	4384	8113	10731	[illegible]	4845						1084	122101
Anticosti						375	[illegible]	417		1774										91			278				168	3132
St. George						[illegible]	813	873		[illegible]	144			80				180										2847
Sydney						71	[illegible]	1037		1040	1080							80										[illegible]
TOTALS	8165	7813	3447	13179	10275	10016	12888	47888	44084	42880	24818	22580	13280	18014	11115	7888	24888	42284	58382	48819	28888	10803	7880	854	2484	0	17435	[illegible]

Statistics include 2D, 3D and ASC data.
High resolution shallow seismic not included


GREENLAND
APPROXIMATE CNOPB JURISDICTIONAL AREA
OKAK ARCH
CARTWRIGHT ARCH
LABRADOR
QUEBEC
NEWFOUNDLAND
ST JOHN'S
BONAVISTA PLATFORM
HIBERNIA
FLEMISH CAP
BASINS
MESOZOIC
1 SOUTH WHALE
2 WHALE
3 HORSESHOE
4 CARSON/BONNITION
5 JEANNE D'ARC
6 FLEMISH PASS
7 EAST NEWFOUNDLAND
8 ORPHAN
9 HOPEDALE
10 SAGLEK
PALEOZOIC
11 ST ANTHONY
12 ANTICOSTI
13 BAY ST. GEORGE
14 SYDNEY
0 200 400
KM
65° 60° 55° 50° 45° 40° 35°
60° 55° 50° 45° 40°

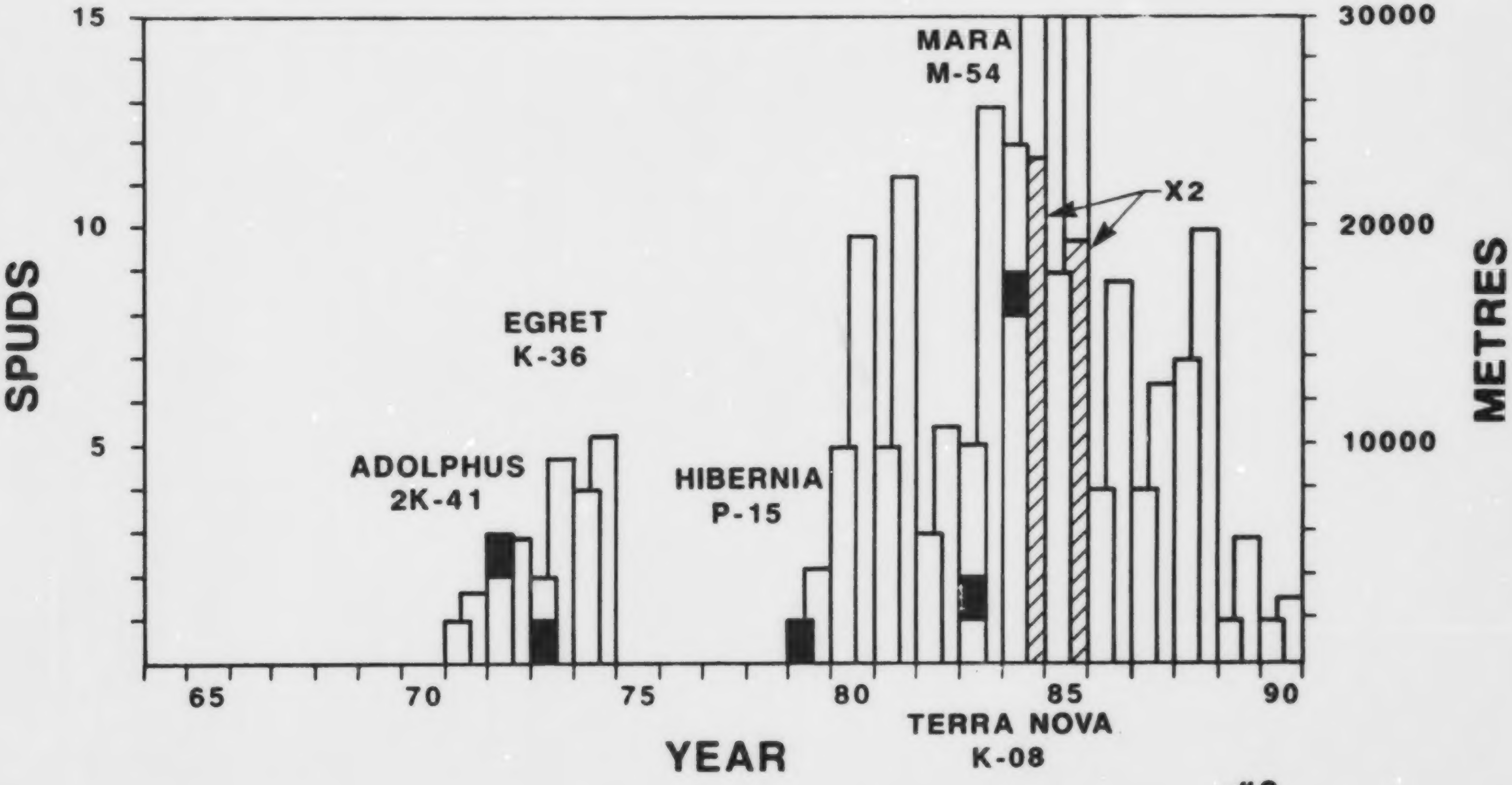
#1

JEANNE D'ARC BASIN
SEISMIC ACTIVITY

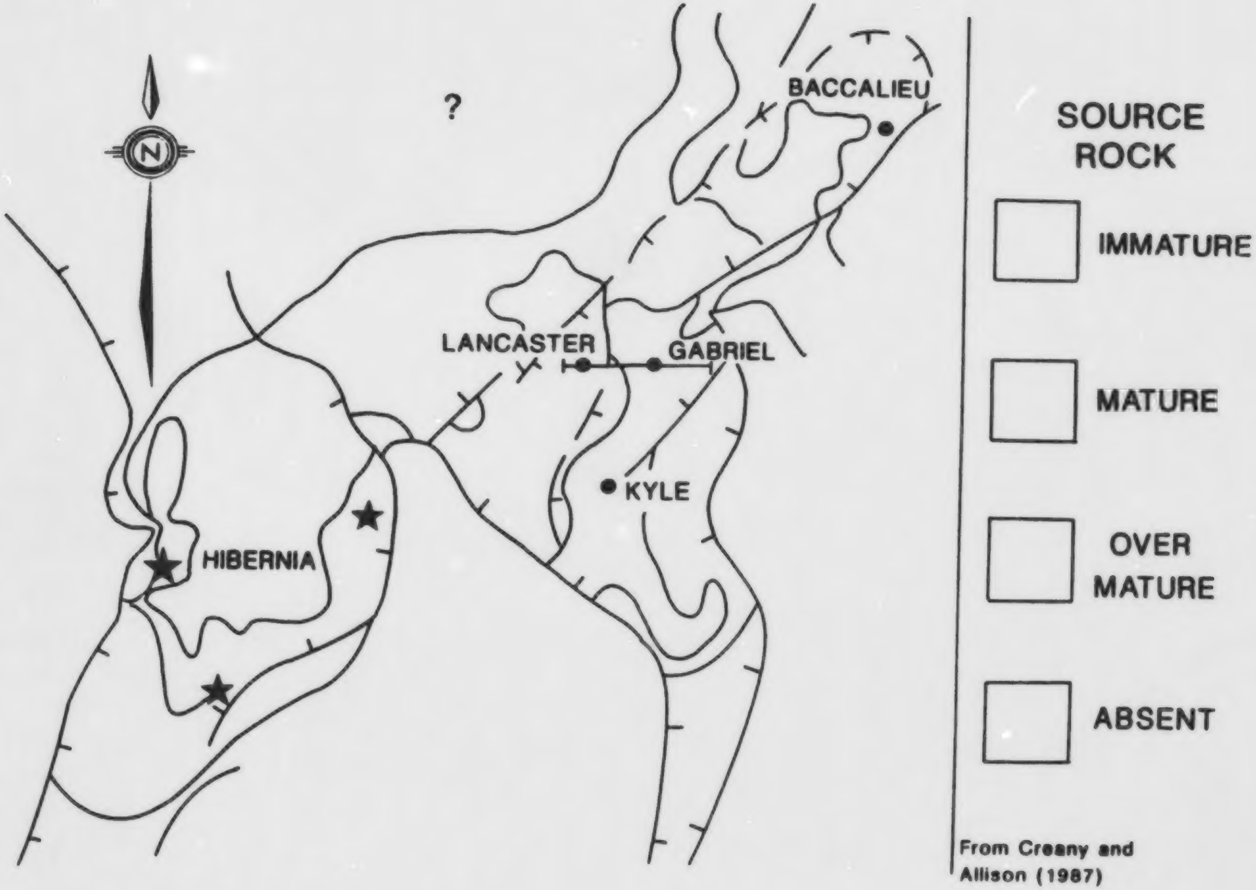


#2

JEANNE D'ARC BASIN DRILLING ACTIVITY

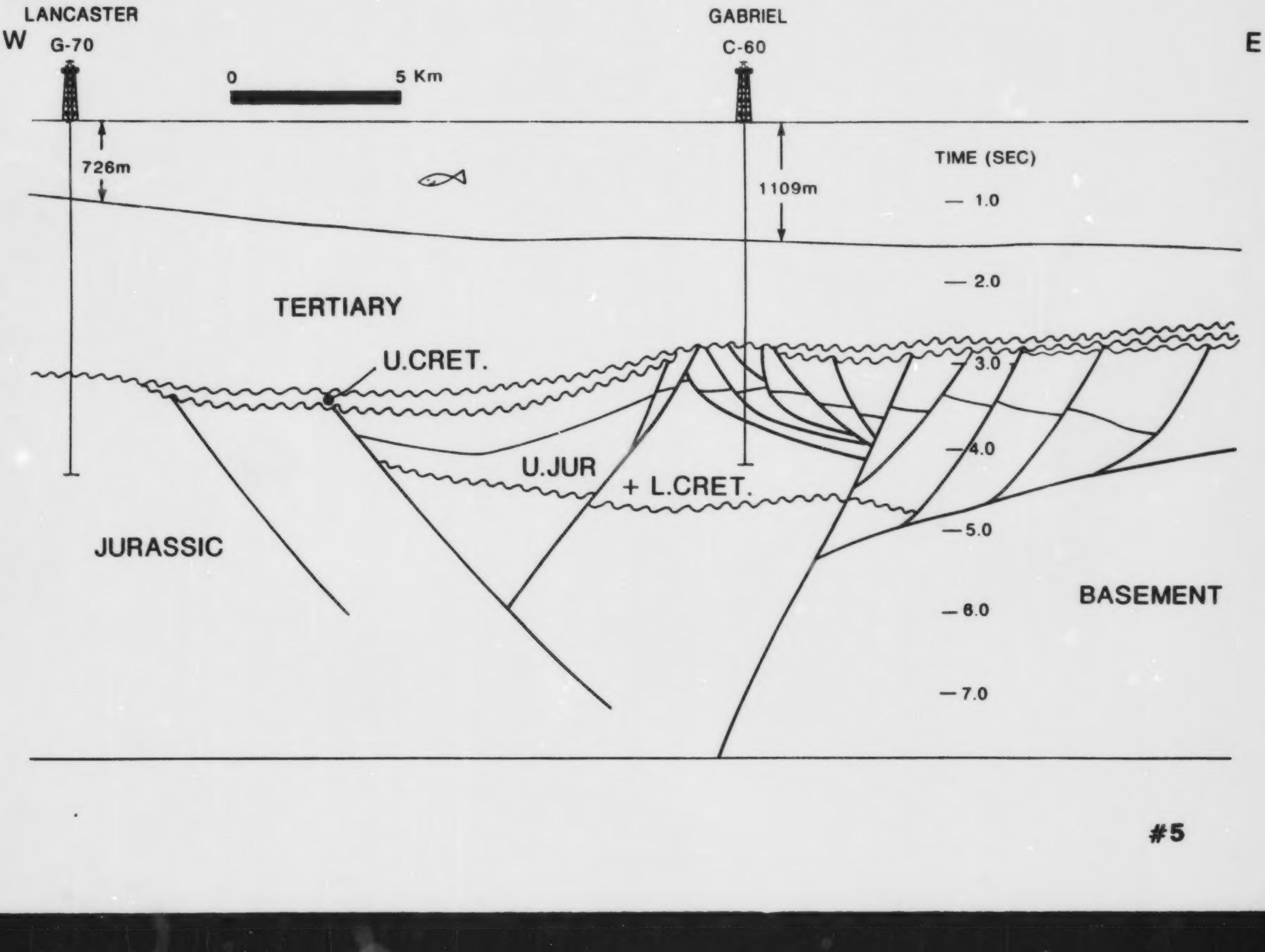


#3


?
BACCALIEU
LANCASTER
GABRIEL
KYLE
HIBERNIA
N
SOURCE ROCK
IMMATURE
MATURE
OVER MATURE
ABSENT

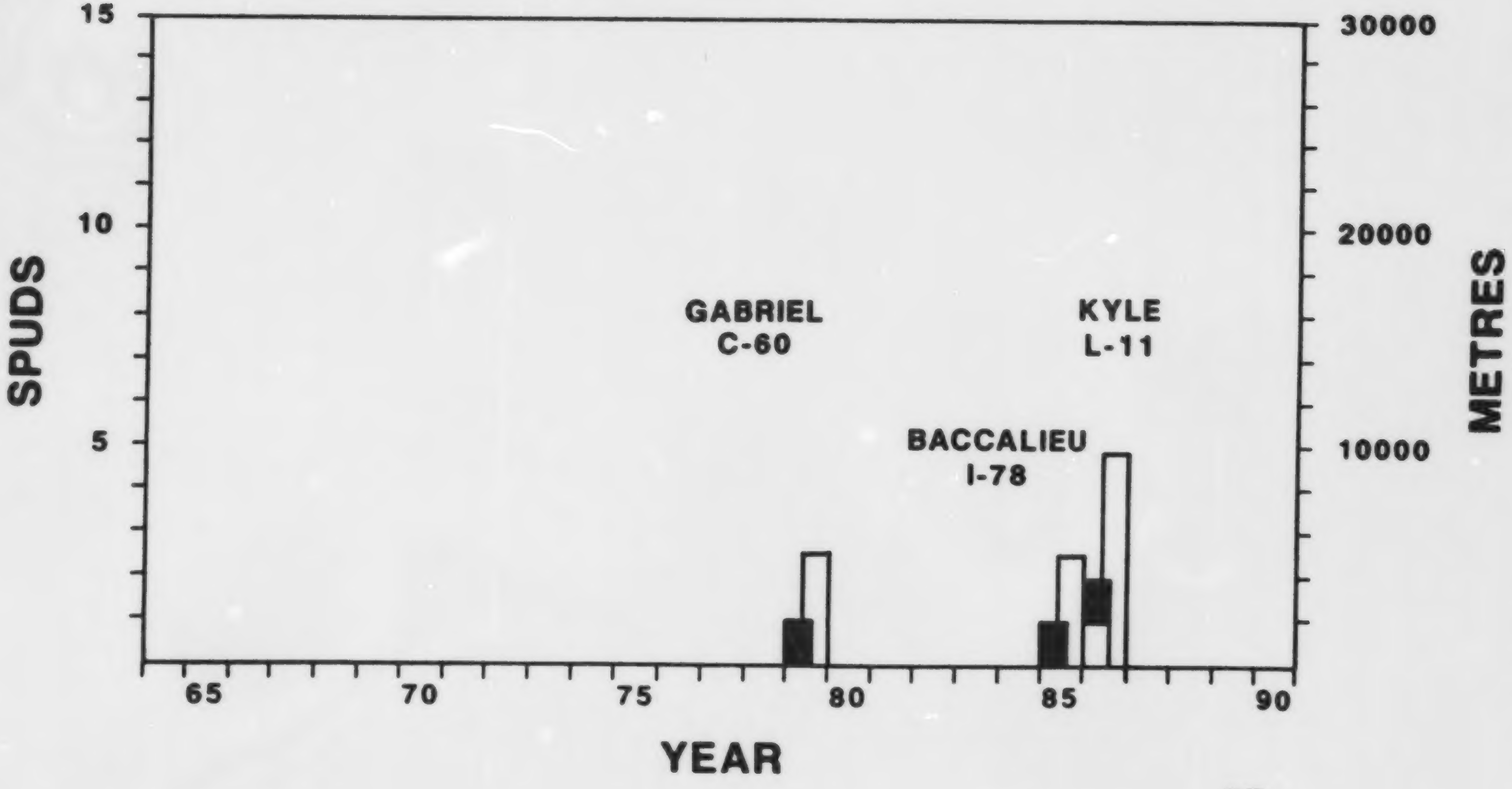
From Creany and Allison (1987)

#4


LANCASTER
G-70
W
0
5 Km
GABRIEL
C-60
E
726m
1109m
TIME (SEC)
— 1.0
— 2.0
— 3.0
— 4.0
— 5.0
— 6.0
— 7.0
TERTIARY
U.CRET.
U.JUR
+ L.CRET.
JURASSIC
BASEMENT

#5

FLEMISH PASS BASIN
DRILLING ACTIVITY



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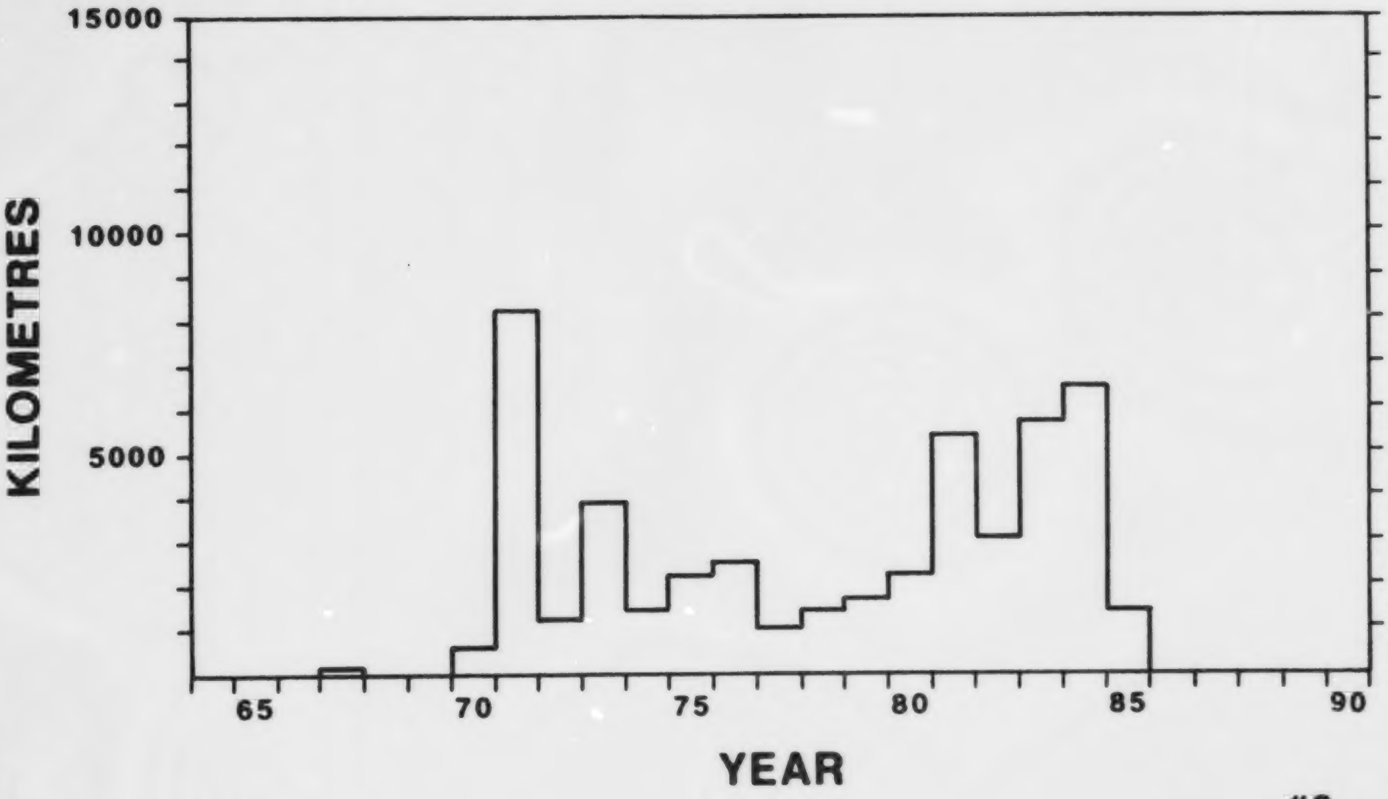
FLEMISH PASS BASIN
SEISMIC ACTIVITY



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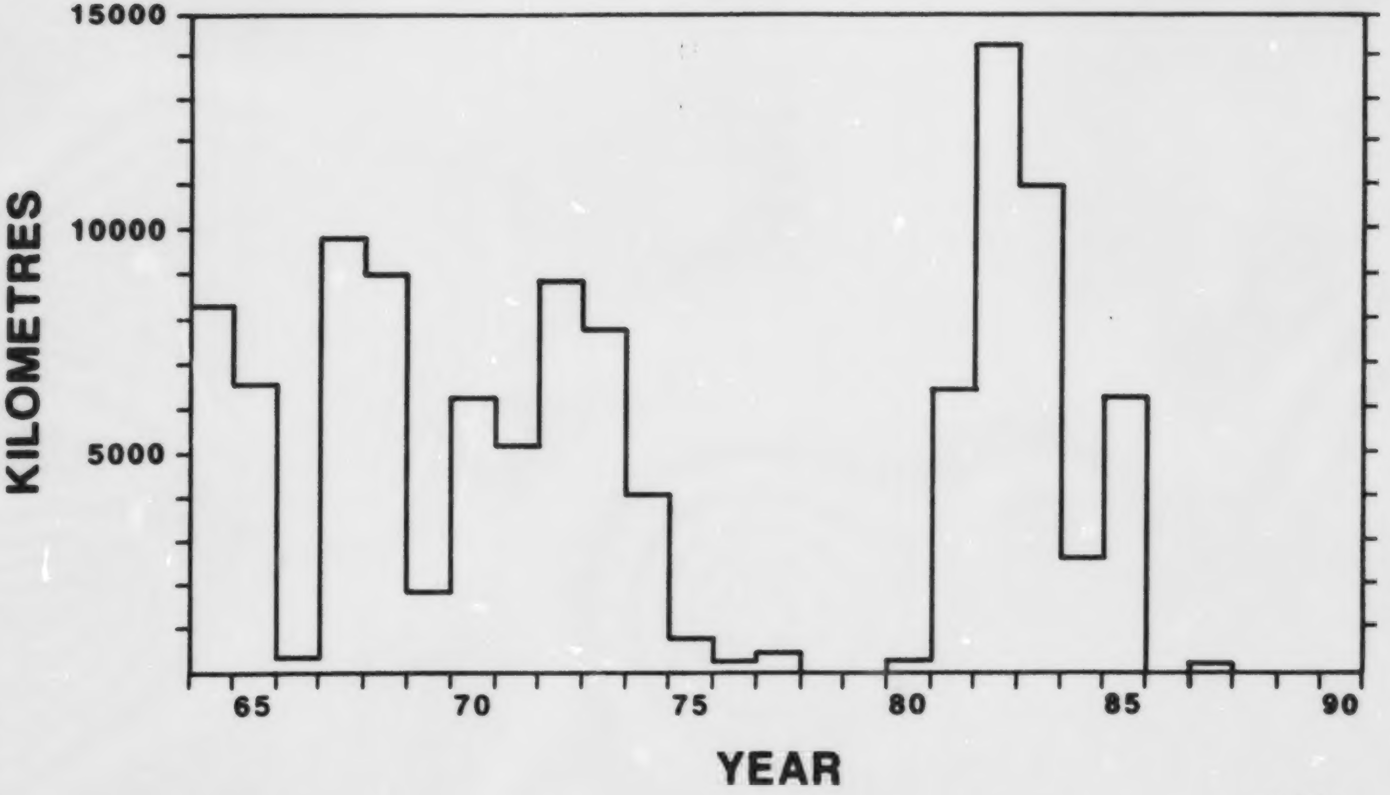
SOUTH GRAND BANKS
SEISMIC ACTIVITY



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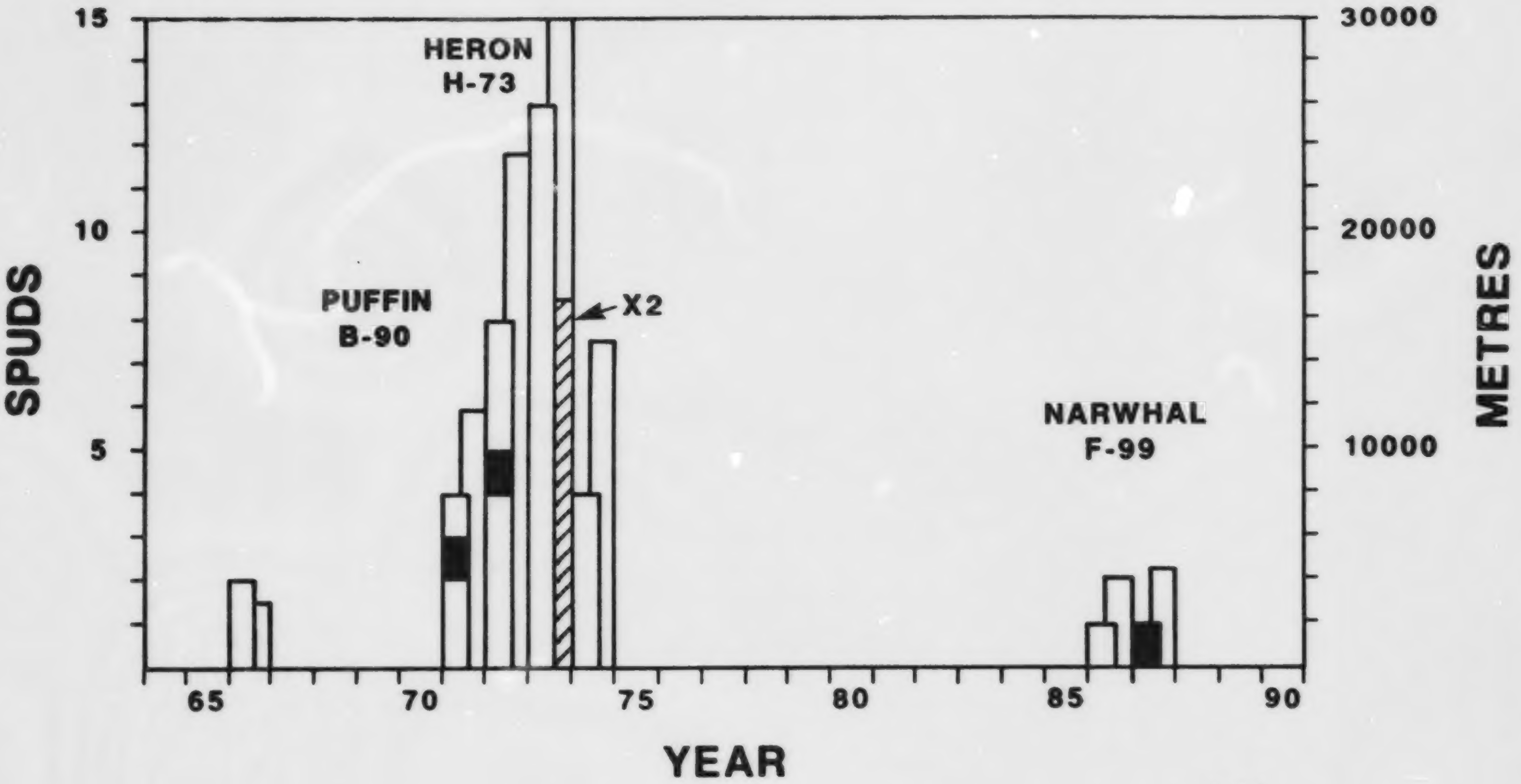
SOUTH GRAND BANKS
DRILLING ACTIVITY



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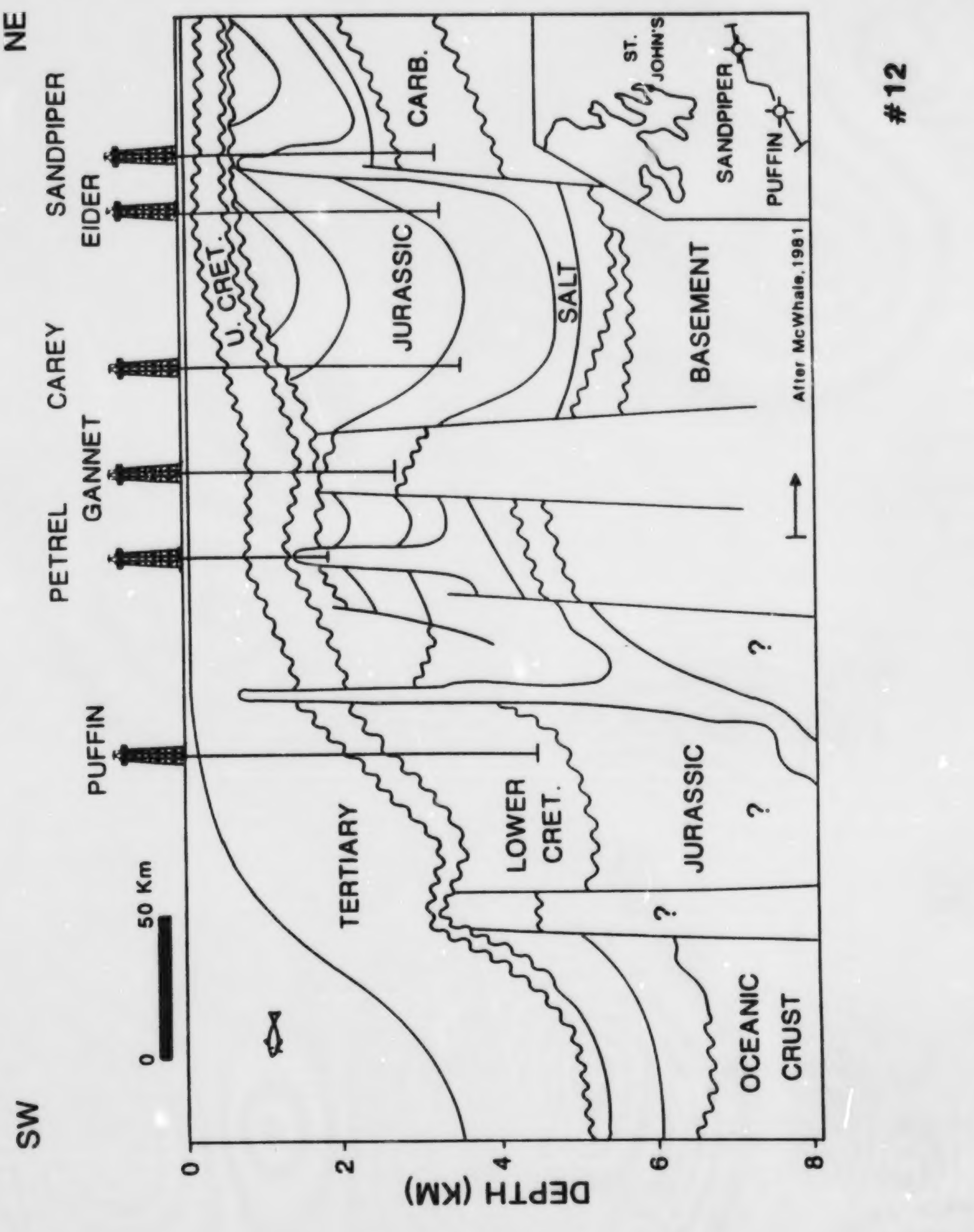
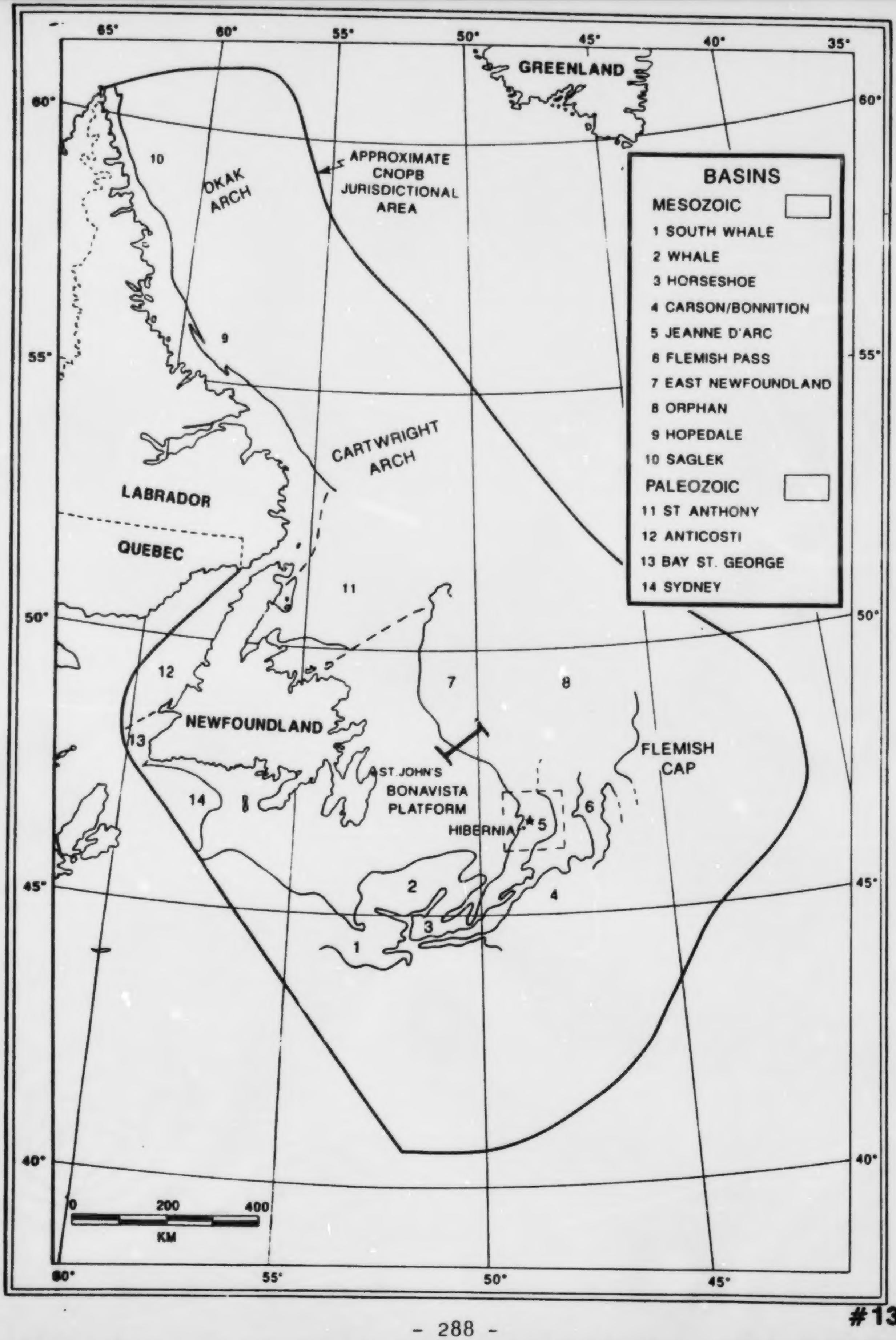

SW
NE
PUFFIN
PETREL
GANNET
CAREY
EIDER
SANDPIPER
0
50 Km
TERTIARY
LOWER CRET.
JURASSIC
?
OCEANIC CRUST
U. CRET.
JURASSIC
SALT
BASEMENT
CARB.
ST. JOHN'S
SANDPIPER
PUFFIN
DEPTH (KM)
0
2
4
6
8

After McWhale, 1981

#12


GREENLAND
APPROXIMATE
CNOPB
JURISDICTIONAL
AREA
OKAK
ARCH
CARTWRIGHT
ARCH
LABRADOR
QUEBEC
NEWFOUNDLAND
ST. JOHN'S
BONAVISTA
PLATFORM
HIBERNIA
FLEMISH
CAP
1
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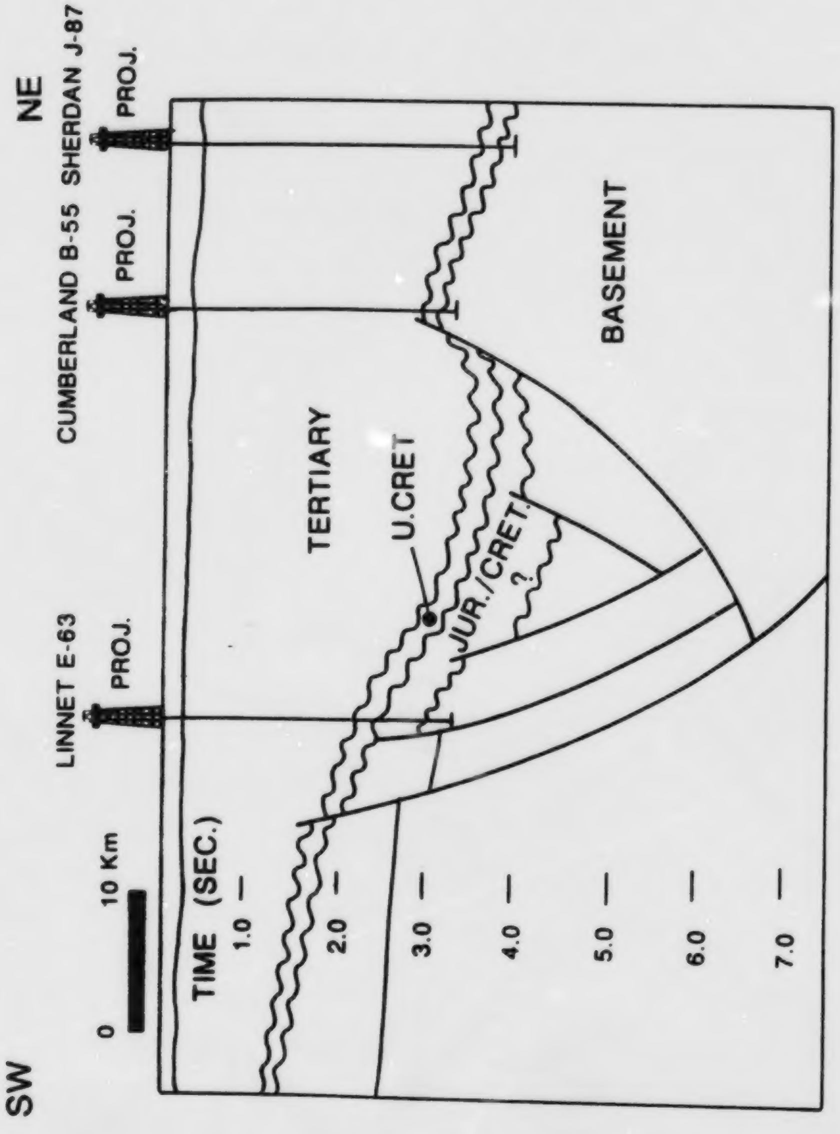
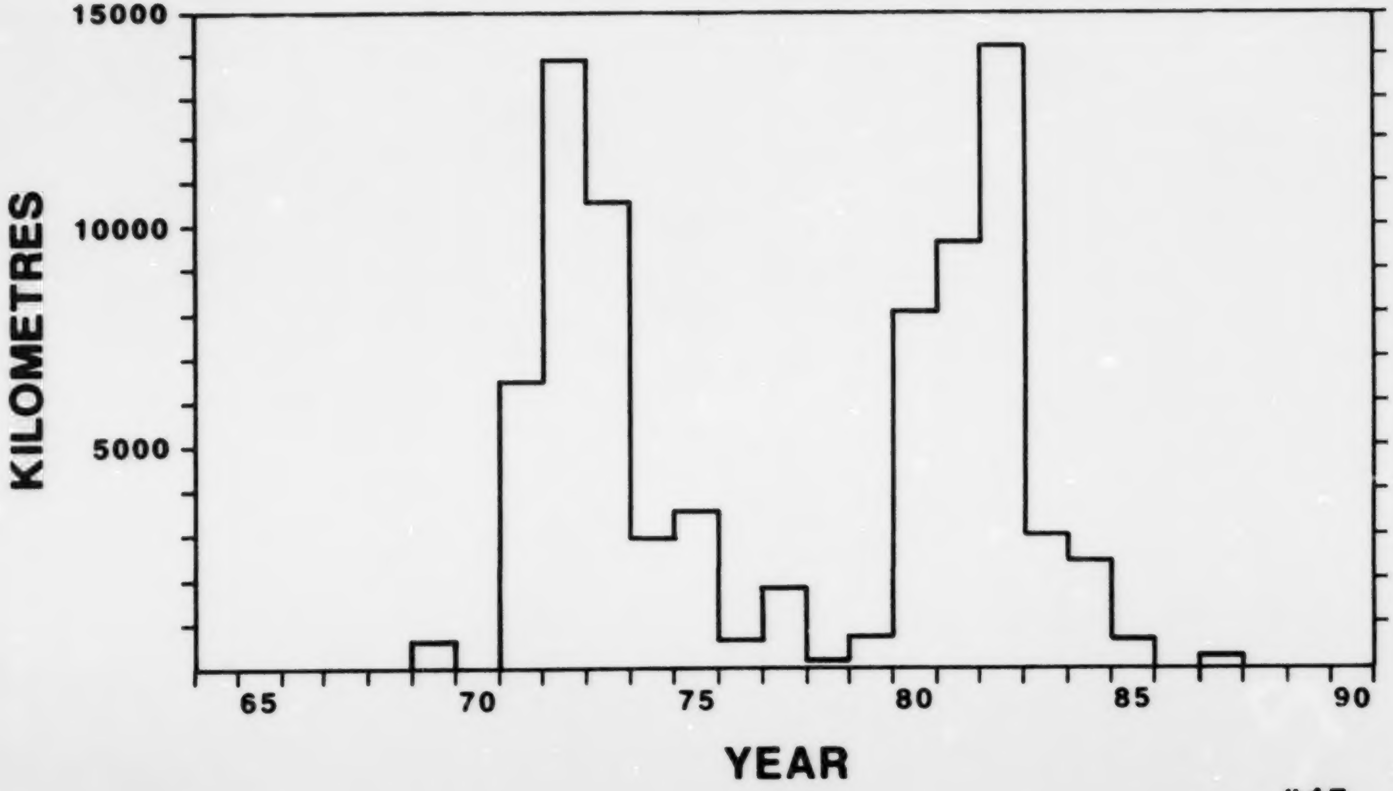
BASINS
MESOZOIC
1 SOUTH WHALE
2 WHALE
3 HORSESHOE
4 CARSON/BONNITION
5 JEANNE D'ARC
6 FLEMISH PASS
7 EAST NEWFOUNDLAND
8 ORPHAN
9 HOPEDALE
10 SAGLEK
PALEOZOIC
11 ST ANTHONY
12 ANTICOSTI
13 BAY ST. GEORGE
14 SYDNEY
65°
60°
55°
50°
45°
40°
35°
0
200
400
KM

#13


SW
NE
LINNET E-63
PROJ.
CUMBERLAND B-55
PROJ.
SHERDAN J-87
PROJ.
0
10 Km
TIME (SEC.)
1.0
2.0
3.0
4.0
5.0
6.0
7.0
TERTIARY
U.CRET
JUR./CRET.
?
BASEMENT

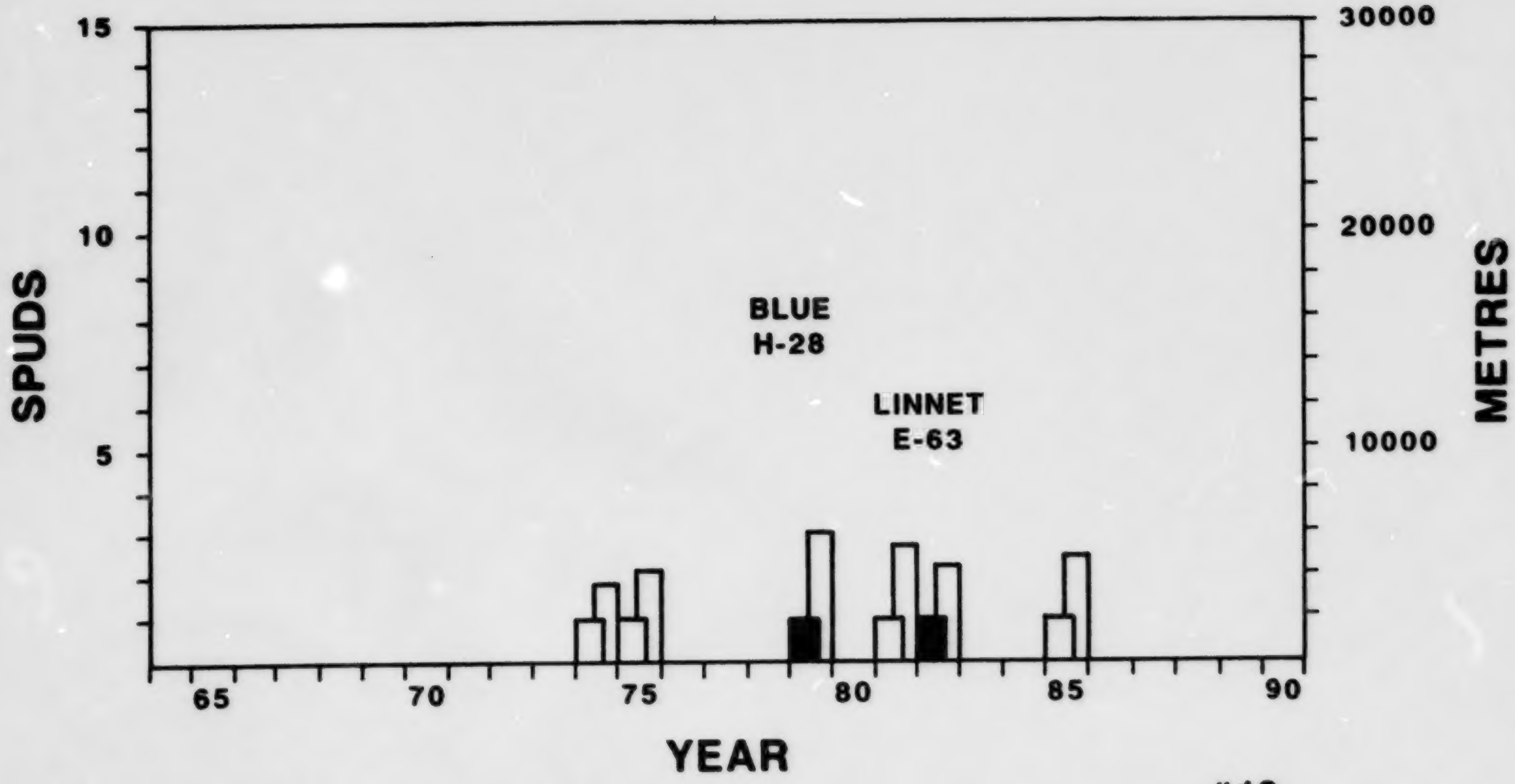
#14

EAST NFLD / ORPHAN BASINS
SEISMIC ACTIVITY



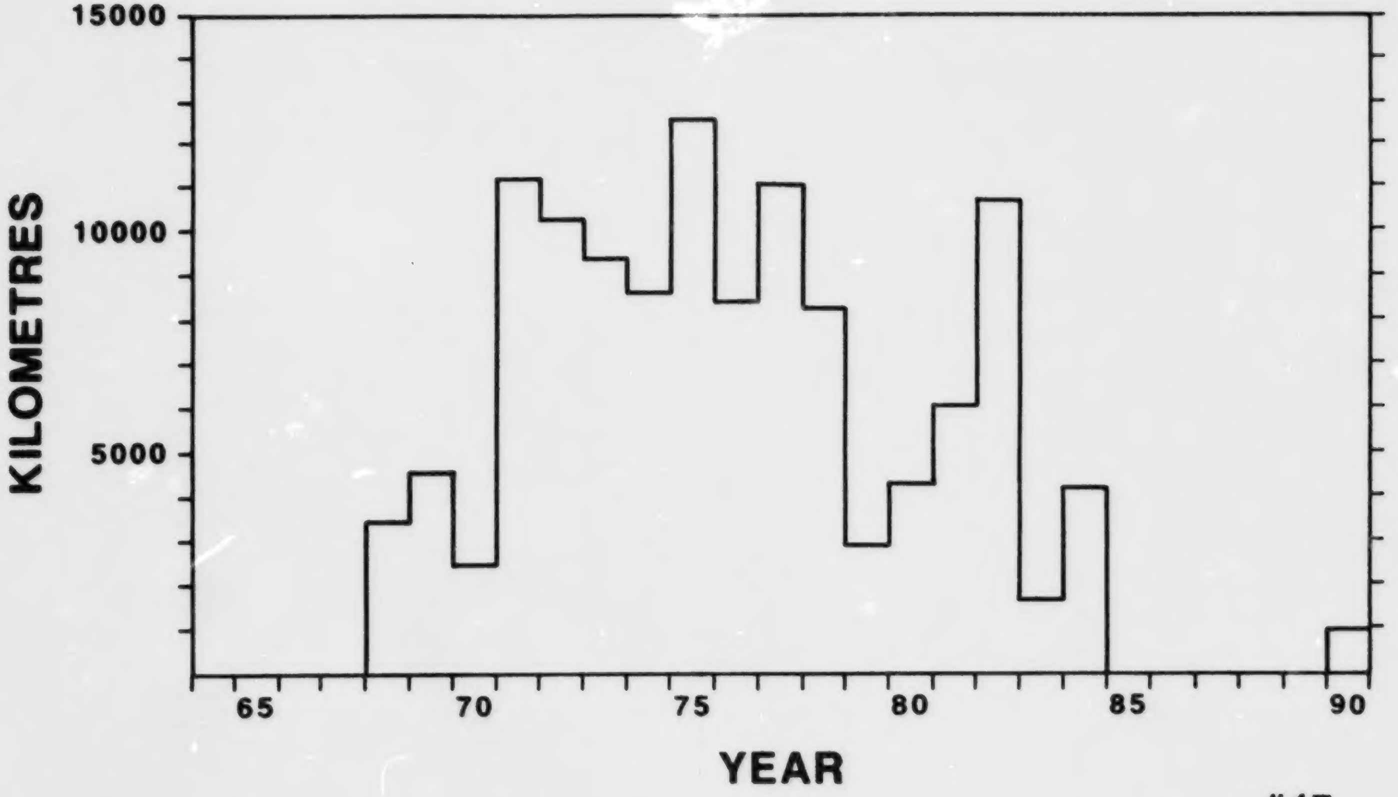
#15

EAST NFLD / ORPHAN BASINS
DRILLING ACTIVITY



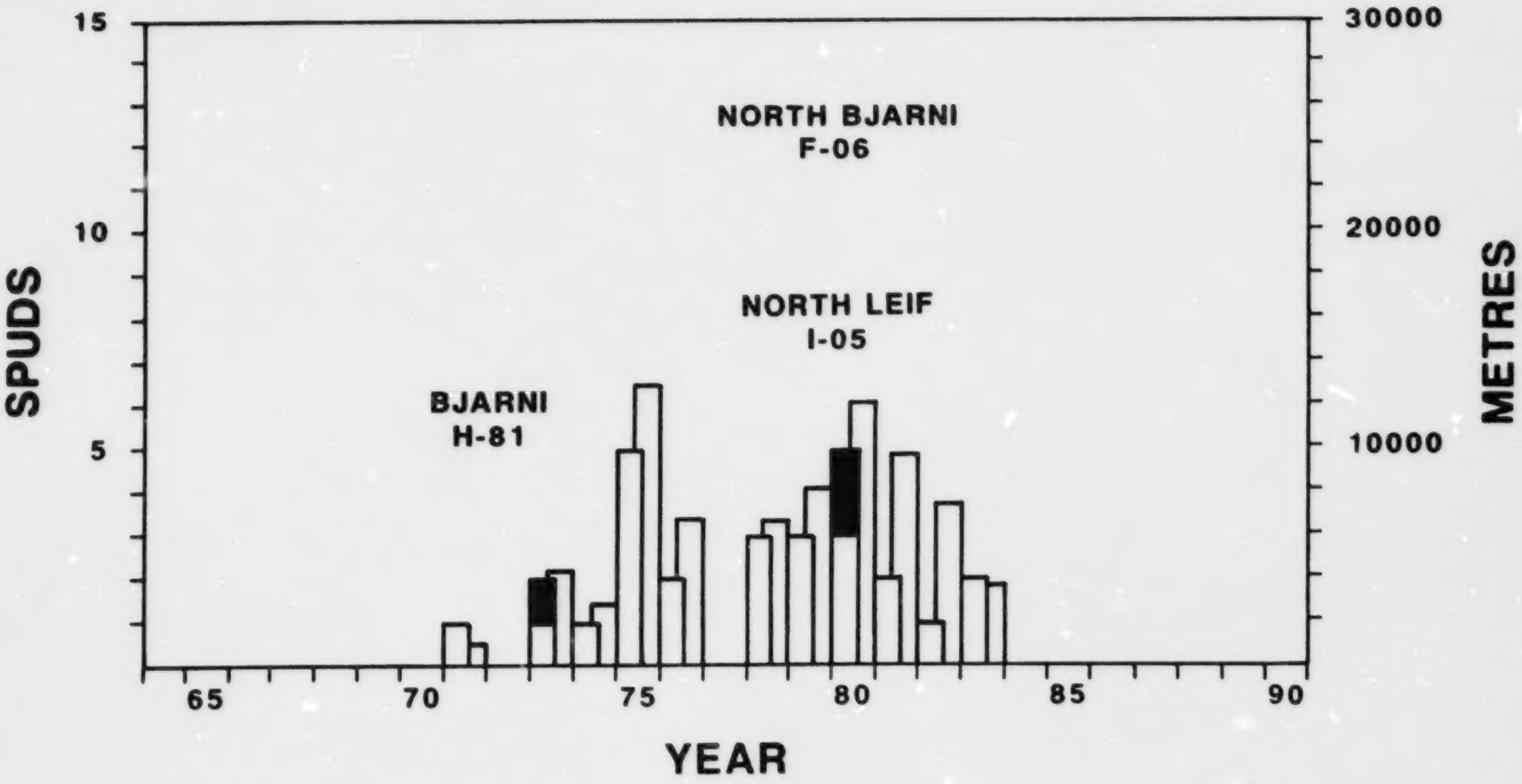
#16

LABRADOR BASINS
SEISMIC ACTIVITY



#17

LABRADOR SHELF DRILLING ACTIVITY



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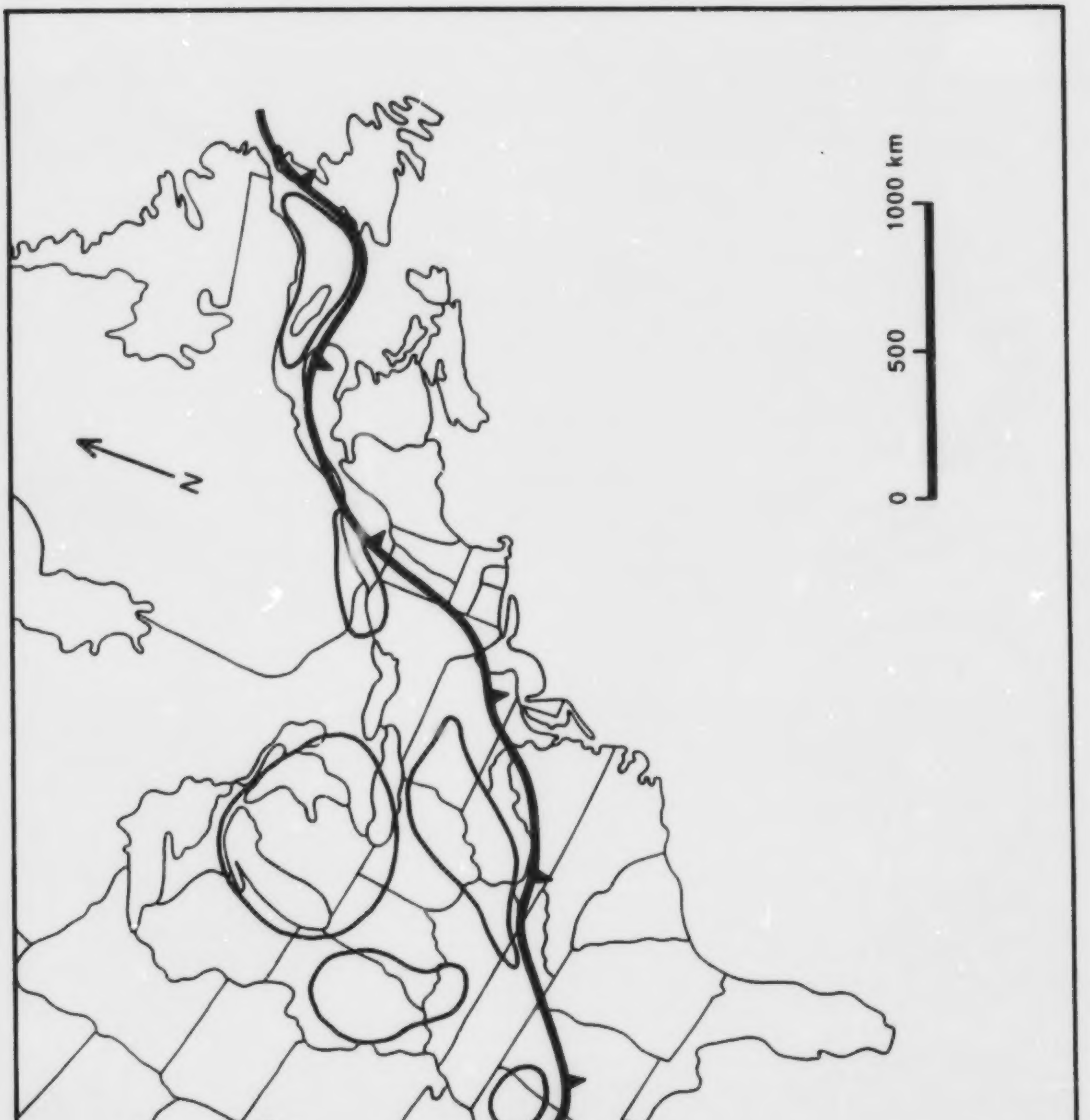
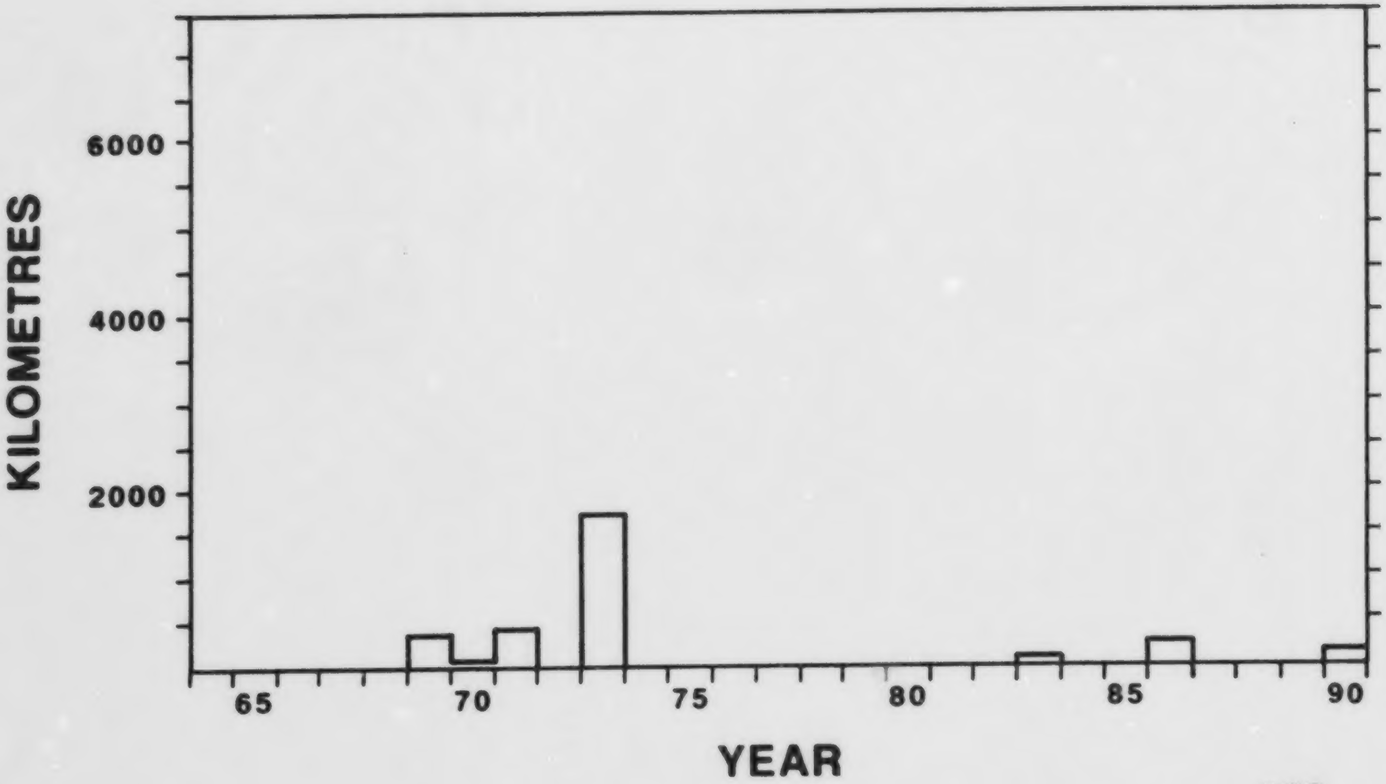
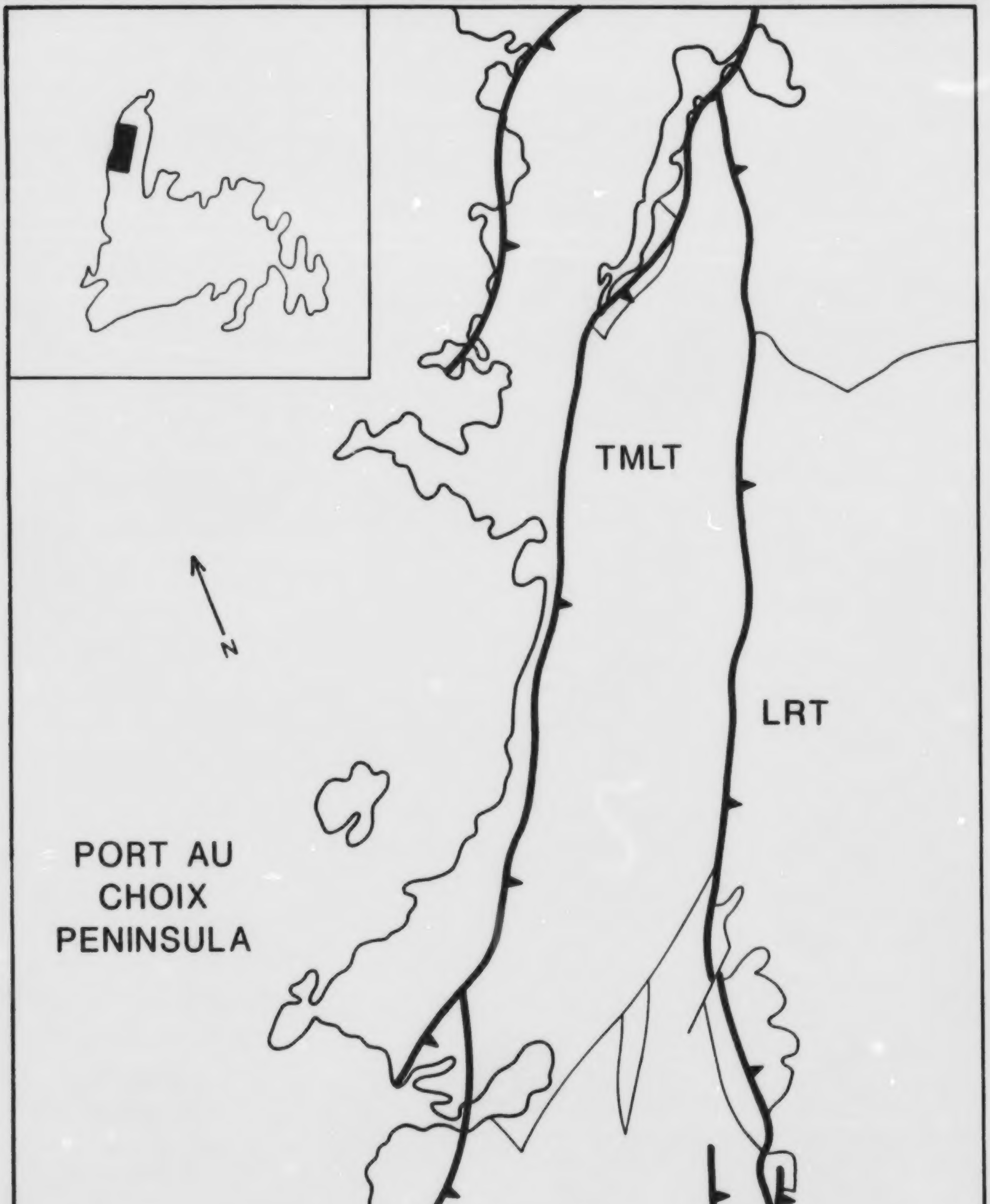

N
0
500
1000 km

#19

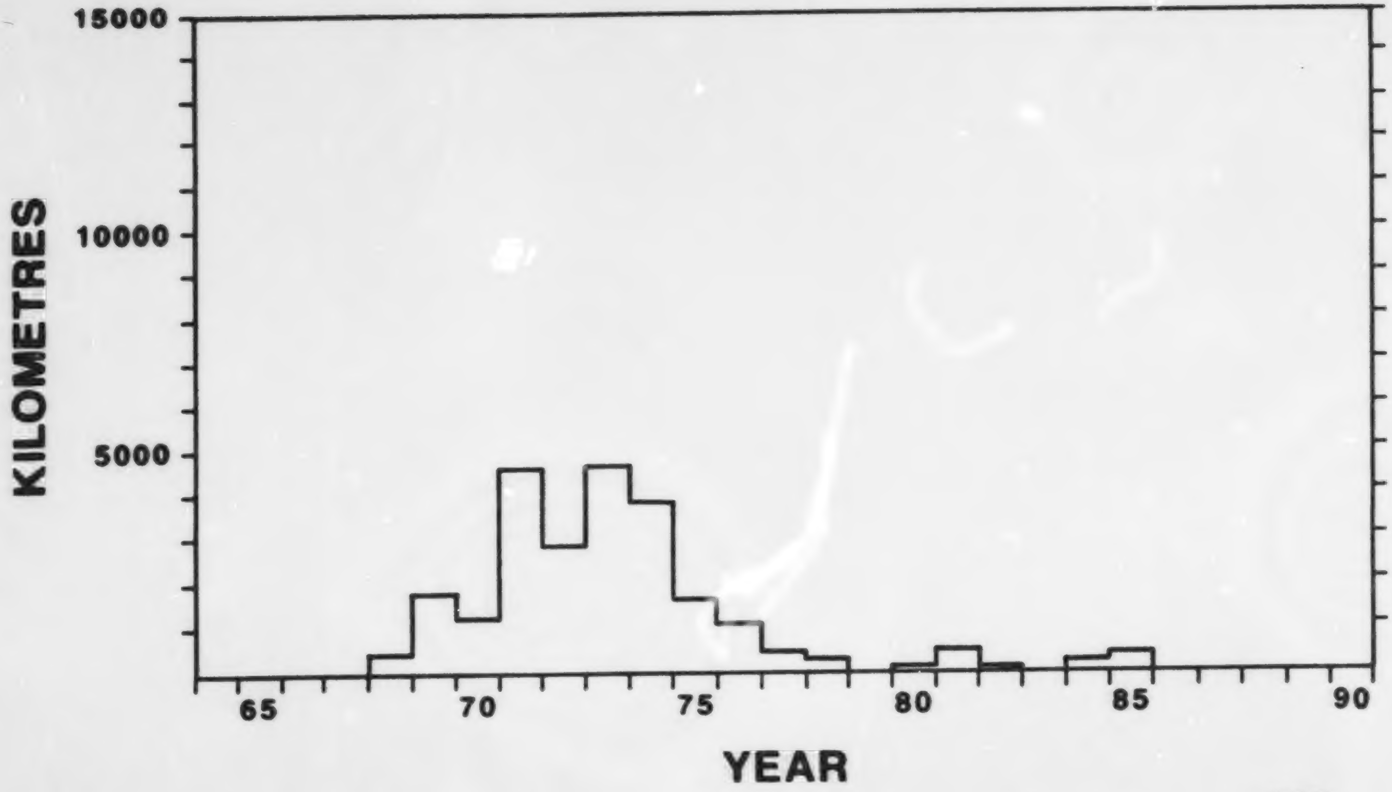
ANTICOSTI BASIN
SEISMIC ACTIVITY




TMLT
LRT
PORT AU CHOIX PENINSULA
N
0
5
10 km

#21

CARBONIFEROUS BASINS
SEISMIC ACTIVITY



#23

SPEAKER : GARY C. BRUCE

COMPANY : PETRO-CANADA RESOURCES

LOCATION: CALGARY, ALBERTA

TOPIC : OFFSHORE NEWFOUNDLAND: CANADA'S NEXT MAJOR OIL PRODUCTION AREA

BIOGRAPHY: *Gary Bruce was born and educated in Nova Scotia, receiving an Applied Science Degree from Acadia University and a Bachelor of Engineering Degree from the Technical University of Nova Scotia. He has over 22 years of experience in the canadian oil industry in such areas as conventional oil and gas, oil sands, research and development, corporate development and the development of canada's frontier resources. He is Vice-President of the New Development Department for Petro-Canada, responsible for Petro-Canada's development of oil sands and Canadian frontier assets.*

OFFSHORE NEWFOUNDLAND:

CANADA'S NEXT MAJOR OIL PRODUCING REGION (?)

G.C. BRUCE
VICE-PRESIDENT, NEW DEVELOPMENT
PETRO-CANADA RESOURCES
CALGARY, ALBERTA

Good morning ladies and gentlemen. It is a pleasure to be here with you today at this Newfoundland Offshore Industries Association conference. I have participated in NOIA conferences in the past and have found them timely and informative. As we stand here on the threshold of Newfoundland offshore development, it is indeed timely that we reflect for a moment on the question of "Where to from here?".

In 1979, I became involved with the development of offshore Newfoundland oil with the discovery of Hibernia. Since that time, with the exception of a few years hiatus to pursue other opportunities, I have spent a considerable portion of my working days looking for the key to economically developing oil found off the East Coast of Canada. While it took over 11 years to get Hibernia under construction, I believe we are now finally on the threshold of a long-term exploration and development era for offshore Newfoundland. However, the title of my address today has a question mark attached to it. There are still a number of factors that could work against this occurring. Many of you here today will have a major influence on the final outcome. I hope my remarks will help you decide that Newfoundland truly is positioned to become a major oil producing province and that there is life after Hibernia!

KEY MESSAGES

In my remarks this morning on the outlook for the development of a viable offshore industry on the East Coast, I want to leave you with three key messages:

One, Canada is becoming a major importer of light crude oil and could be importing half of its requirements by the year 2000;

Two, The exploration for and development of oil prospects in the Grand Banks region offers an economically and technically viable alternative to the importation of foreign crudes;

Three, the development of competitive sources of domestic oil supply versus the purchase of foreign crudes will have a major positive impact on the economic well being of Canada and, particularly, Newfoundland.

CANADIAN SUPPLY/DEMAND OUTLOOK

Canada produces both light and heavy crude oils. As many of you may know, Canada's ability to use heavy crudes, including bitumen, is limited relative to the volumes produced. In contrast, we do not produce nearly enough light crude oil to meet our domestic requirements. It has been estimated that by the end of this decade, Canada could be importing about 500 thousand barrels per day of light oil or roughly 40% its requirements. If you believe that Canada should not be so dependent on crude imports, where are we to look for additional domestic sources of supply?

CANADIAN CRUDE SUPPLY REGIONS

Looking at the Western Canadian Sedimentary Basin, we see a mature basin where industry has already found 80% of the estimated conventional oil in place. This leaves about 3 to 4 billion barrels of recoverable oil left to find, and it will be both difficult and expensive oil to discover. In the 1980's, the largest Western Canadian oil field developed contained a few tens of million barrels of recoverable oil, a far cry from the 100 million-barrel-plus pools found in the 1950's and 1960's. Smaller pool sizes and reduced prospects have resulted in finding costs increasing to $6 - 8 U.S./bbl. The industry will still explore for oil in Western Canada. However, we will neither be able to replace reserves produced nor increase production which began to decline over 15 years ago.

An obvious second supply choice is the massive oil sands deposits of Alberta. With over a trillion barrels of bitumen in place, this resource is large enough to meet our requirements for a long time. Unfortunately, to extract the bitumen and upgrade it to compete with imported light crude requires a world crude price in the order of $30 U.S./bbl. Improvements in technology (e.g., horizontal drilling, dredging, slurry pipelining, cold water extraction) and rising crude prices could enhance the economic viability of this supply source but it will not likely be in this decade.

Another potential supply source is the Mackenzie Delta, Beaufort Sea and Arctic Islands regions of the North. However, the lack of a transportation system to move the crude 2000 miles to market and of a large enough accumulation of oil to support the construction of such a transportation infrastructure means identification of additional oil supplies and substantially higher crude prices will be required before oil from these regions becomes economic.

That leaves the East Coast of Canada, and in particular the oil prone Grand Banks area, as potentially the most attractive, near-term source of crude oil to offset Canada's declining light oil production. The potential oil reserves of this area are certainly large. You have heard the previous speakers describe the high potential that exists for additional significant discoveries. This potential is larger than that remaining in Western Canada. We are still very early in the exploration stages, with only approximately 1.6 billion barrels discovered (CNOPB) or about one-sixth of what we may expect to find. This equates to the year 1950 in the exploration and development history of the Western Canadian Basin. With pool sizes in excess of 100 million barrels recoverable and exploration finding costs less than $2 U.S./bbl., this region is beginning to look very attractive.

GRAND BANKS DISCOVERIES

Most of the oil discovered to date in the Jeanne d'Arc Basin is in the Hibernia, Terra Nova, Hebron, West Ben Nevis and Whiterose fields. The field leading the development of this area is Hibernia. Recoverable reserves in the field are estimated to be in excess of 525 million barrels. This makes Hibernia the largest conventional oil field discovered in Canada since the Swan Hills field was discovered in 1957.

HIBERNIA

Hibernia is a massive endeavour, incorporating some major improvements in existing technology. It is located 200 miles out in the North Atlantic Ocean in 260 feet of water in an area prone to icebergs and pack ice and North Atlantic weather. Because of the huge scale of the investment and the fact that it is the first project of its nature to be built in Canada, it was necessary for governments to share substantially in the risks, and thus the rewards, of the project. At peak production, Hibernia is expected to produce up to 150,000 bpd of oil or about 15 - 20% of Canada's light oil productive capacity at the time it comes on stream.

The Hibernia Project uses a bottom-founded structure from which to produce the oil present in the underlying reservoirs, with oil delivered to the facilities through wells drilled both from the platform and from separate drilling vessels. The wells drilled from mobile drilling units will be completed subsea and the oil delivered to the Hibernia platform through subsea flow lines. These gravity-based structures have worked well in the harsh climates of the North Sea and are relatively economical when the reserves associated with the field are large. However, for small and medium size fields (less than 500 million barrels) in the water depths and climatic conditions prevalent on the Grand Banks, fixed gravity systems are not economic under foreseeable crude prices. Of the discoveries made to date on the East Coast, only Hibernia approaches the size of field needed to justify the high capital costs and long lead times associated with a GBS. In our efforts to unlock a technology to make smaller field development economic, Petro-Canada was drawn to the floating production systems now being contemplated and used more and more in the North Sea to produce what the British and Norwegians call "marginal fields".

Exploration results to date and the expected distribution of pool sizes in the basin suggest that most of the fields to be found on the Grand Banks will be much smaller than Hibernia. We expect floating systems will encourage the oil explorer to begin searching for those fields previously not expected to be economic to develop using GBS technology. Obviously, the development of Hibernia will result in the development of an infrastructure that will assist the development of these smaller pools but it will be floating systems that will establish a sustainable industry offshore Newfoundland.

The next project to be developed in the basin will most likely be Terra Nova. It is this project we believe will pioneer the use of a floating production system in Canadian waters. With reserves in excess of 300 million barrels, Terra Nova is ideally suited to lead the way in utilizing this type of production system. The subsea system and topside facilities associated with Terra Nova will be similar to those used at Hibernia. However, the similarity ends there.

FLOATING SYSTEMS

As operator of Terra Nova, Petro-Canada evaluated a large number of concepts before concluding that the most effective means of development was a floating system. A floating system, such as the one proposed for Terra Nova, meets or exceeds all criteria for technical soundness, risk limitation, environmental acceptance and economic viability.

The slide shows an artists conception of the system which the project participants propose to use to recover the oil at Terra Nova. The system is based on a ship-shape vessel with storage in the hull and processing equipment mounted on the ship's deck. The crude is offloaded from the production-storage vessel into shuttle tankers for transport to the markets.

TERRA NOVA PROJECT DIMENSIONS

This all sounds simple enough. But let me take a moment to give you some idea of the size of the project. The production vessel is about 800 feet long and 140 feet in beam, with a displacement of 120 thousand tons. The vessel would be able to store 650 thousand barrels or about five days of production at peak production rates. It would be turret-moored but would also have a thruster system to enable it to manoeuvre in emergencies. It would also have a quick disconnect system to enable it to move off location in emergencies.

SYSTEM CAPACITIES

The topsides process equipment would be able to produce 125 thousand barrels per day of crude oil and handle a total of 200 thousand barrels per day of produced fluids. The facilities would include compressors capable of reinjecting 100 million cubic feet per day of gas produced in association with the oil. It would also be capable of injecting up to 200 thousand barrels per day of water to assist in maximizing recovery of oil from the reservoir.

PROJECT SUPPORT VESSELS

However, the production vessel would not be the only vessel out there. In fact, the operation requires a whole fleet of support vessels. There would be up to three, 100-120 thousand ton crude tankers to carry the oil to market. These tankers would be double-hulled and ice strengthened to operate year-round in the ice infested waters. Other support vessels could include a semi-submersible rig for drilling and workovers, a multi-purpose vessel for workover and firefighting, a fleet of supply boats for things like resupply, iceberg management, and anchor handling as well as a dedicated standby vessel for potential emergencies.

This armada of production and support vessels will require a significant shore-based support operation if it is to function smoothly. This shore-based support will include technical and operations support and administration, warehousing, helicopter support and catering, to mention just a few. All this operating activity will result in the creation of a significant number of new jobs in Newfoundland. Our preliminary estimate of the total direct workforce required to operate the production system, support vessels, tankers and land-based support exceeds 875 man-years annually.

The net impact on Canada and Newfoundland in particular from the Terra Nova development will be significant. The project will generate, in addition to the direct operating jobs mentioned, government revenues in the form of sales taxes, duties, royalties and income taxes, as well as significant spin-off benefits to the provincial economy in the form of indirect employment and the purchase of goods and services.

SECURITY OF SUPPLY

But why take the risk of developing our East Coast oil prospects? Isn't there enough available oil on the world market and wouldn't it be cheaper to buy offshore? I want to leave you with a few thoughts to consider in arriving at your own conclusions.

Offshore supplies today are sufficient, but demand has been steadily growing world wide. At the same time, conventional sources in the North Sea and the Soviet Union are on decline. While OPEC supply today appears adequate, I don't have to remind you of the unstable nature of oil prices and supply, given what happened in the mid-1980's and during 1990. Do we want to be heavily reliant on imported oil? (It is also interesting to note that the Grand Banks region is ideally suited to supply Eastern Canada and the U.S.A., both areas where imports are expected to increase in the 1990's).

The impact of purchasing an additional half-million bpd of oil in the offshore market by the late 1990's will have a major adverse impact on Canada's balance of payments. The purchase of offshore oil doesn't create a demand for nationally produced goods and services.

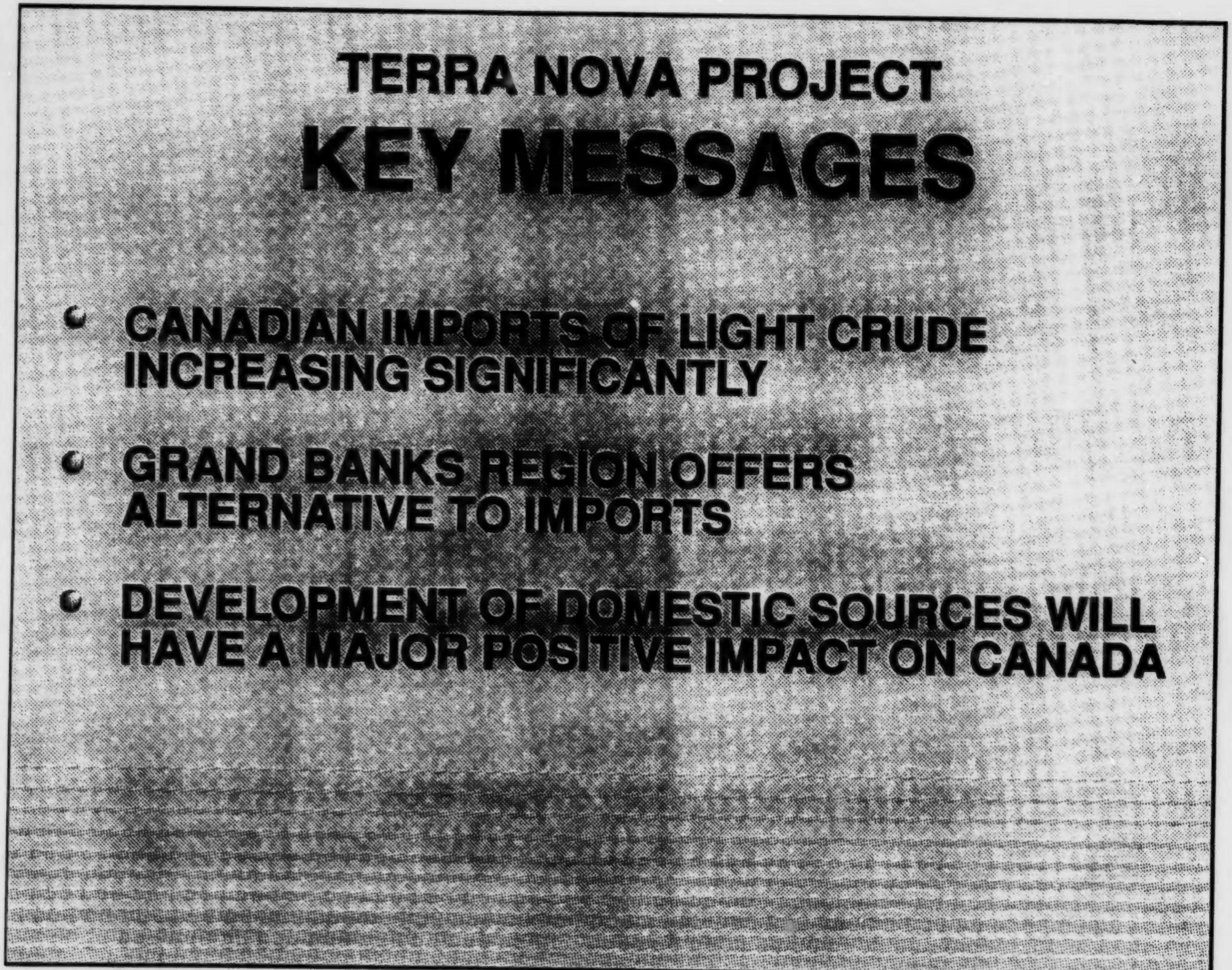
The development of Newfoundland offshore oil supplies will have a positive effect on the East Coast region and on Canada as a whole. The most obvious impact will be the jobs that are created - both direct and indirect - and the significant business opportunities created for Canadian entrepreneurs. Offshore technical expertise will be developed and the ability of Canadian companies to compete internationally for offshore oil development contracts will be greatly enhanced. Also, as I noted previously, government coffers will be enriched as a result of the taxes, royalties and duties paid by the projects.

CONCLUSION

Canada faces a declining ability to produce the light crude oil that it requires. I have suggested some of the options we have to meet this requirement and indicated that I believe that the best alternative is the Grand Banks region. The potential exists for the development of a significant, economically viable offshore oil industry. We also know, by extrapolation from other offshore areas such as the North Sea or the U.S. Gulf Coast, that such development can bring significant long-term benefits to the region. However, if this potential is to be realized, each future project must be allowed to proceed on its own merits and governments must work with industry in the process of development. Petro-Canada believes that future offshore projects can be developed without government grants or loans. However, governments must participate in the development of a fiscal regime that recognizes the high costs and risks of offshore projects and they must also allow projects to proceed on an internationally competitive basis.

Although it is impossible to predict with certainty the exact outcome of the exploration and development activity that is unfolding, the future does look particularly bright for this Province to become Canada's next major producing region.

Thank you very much for your attention this morning.



TERRA NOVA PROJECT

KEY MESSAGES

- CANADIAN IMPORTS OF LIGHT CRUDE INCREASING SIGNIFICANTLY
- GRAND BANKS REGION OFFERS ALTERNATIVE TO IMPORTS
- DEVELOPMENT OF DOMESTIC SOURCES WILL HAVE A MAJOR POSITIVE IMPACT ON CANADA

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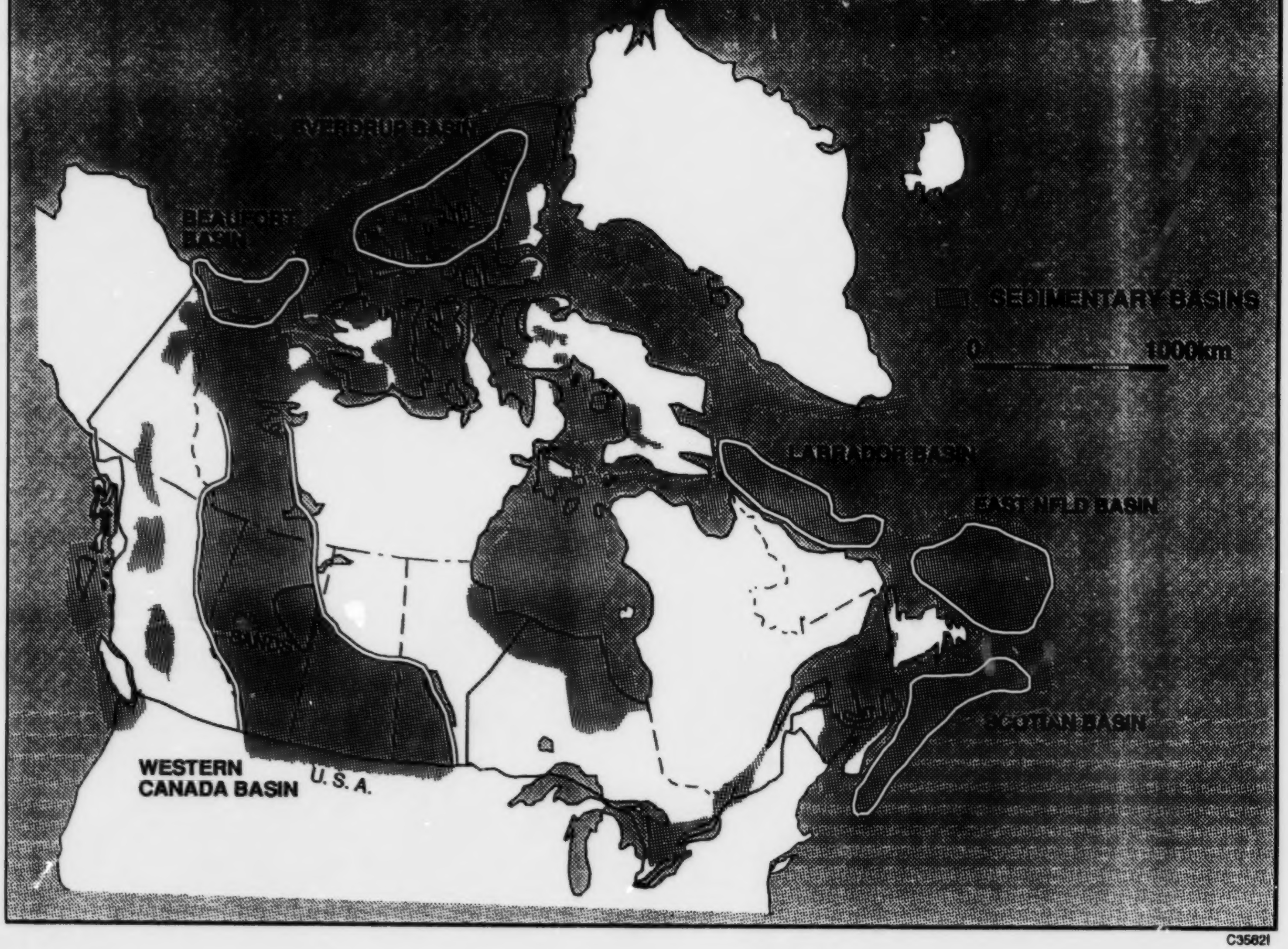
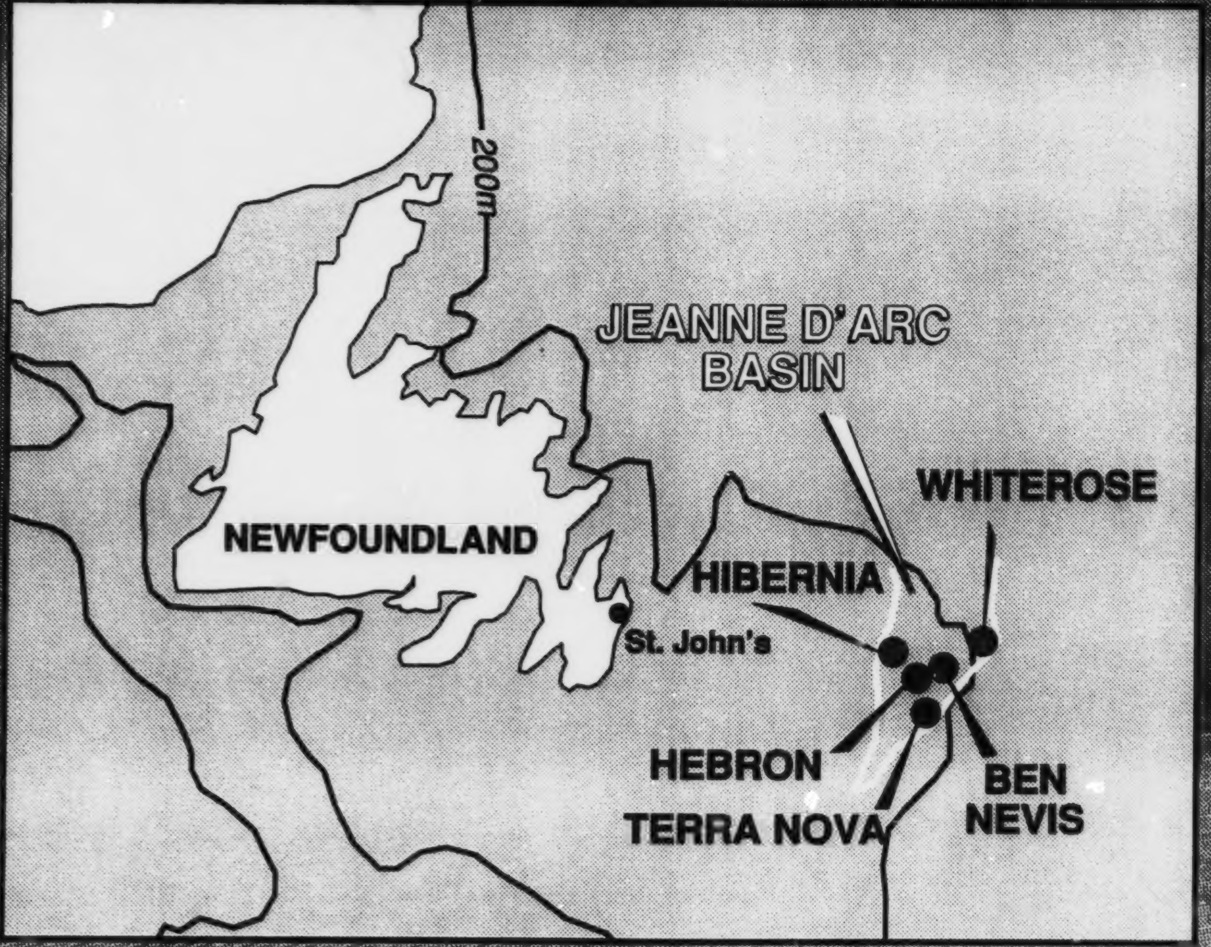
CANADIAN SEDIMENTARY BASINS

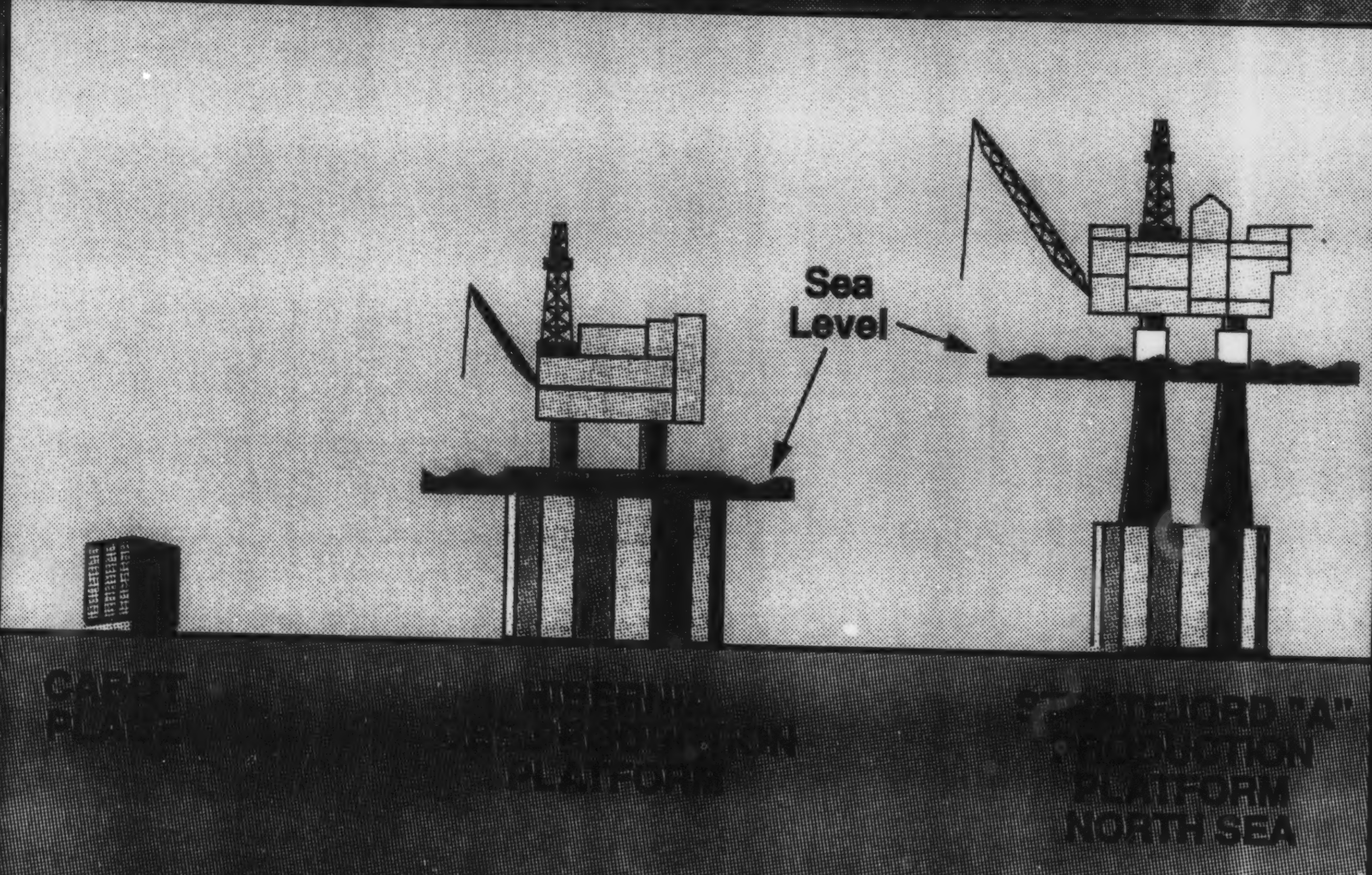

SVERDRUP BASIN
BEAUFORT BASIN
SEDIMENTARY BASINS
0
1000km
LABRADOR BASIN
EAST NFLD BASIN
SANDS
SCOTIAN BASIN
WESTERN CANADA BASIN
U. S. A.
C35821

MAJOR GRAND BANKS
OFFSHORE DISCOVERIES


200m
JEANNE D'ARC BASIN
WHITEROSE
NEWFOUNDLAND
HIBERNIA
St. John's
HEBRON
TERRA NOVA
BEN NEVIS

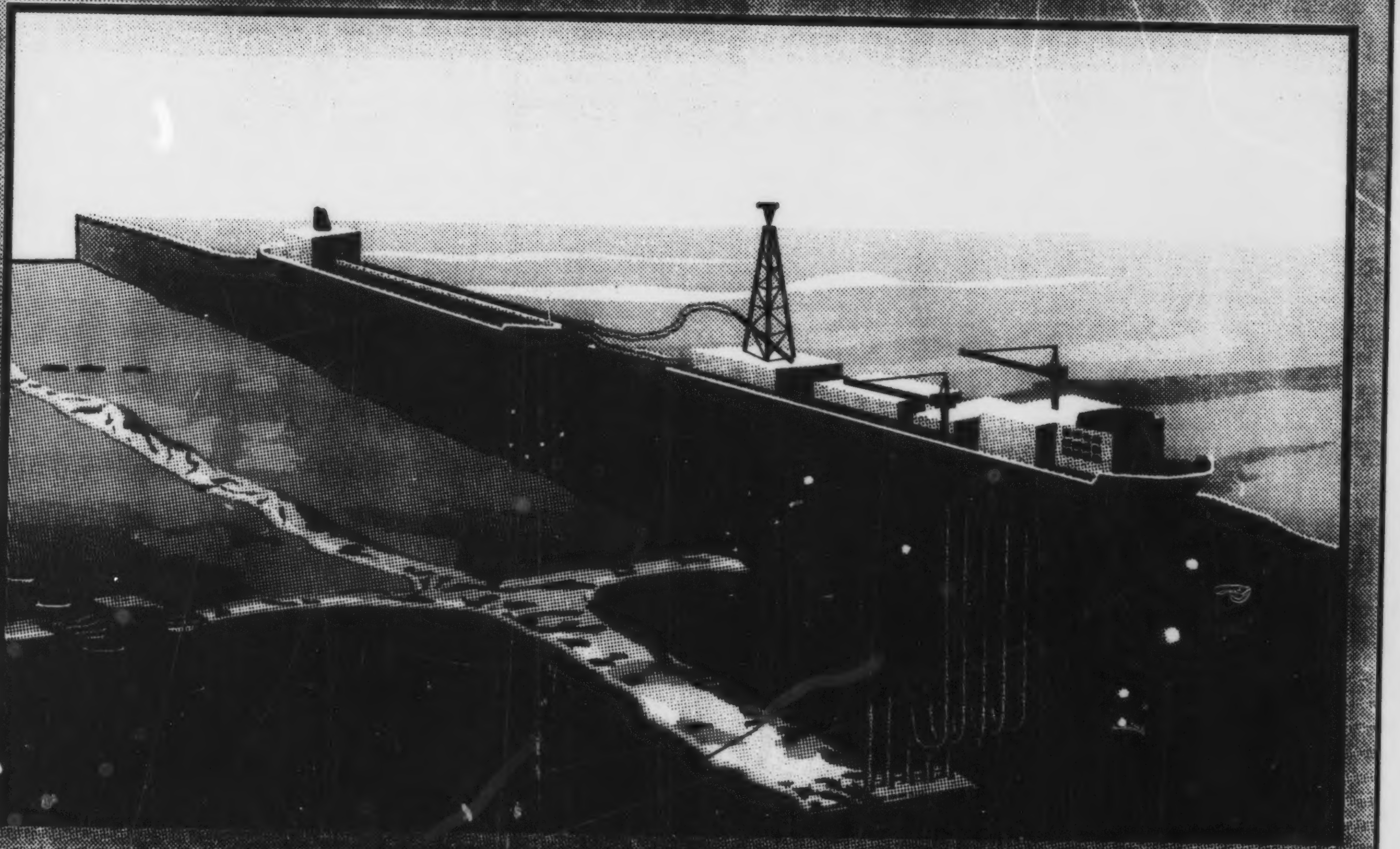
C3582A

HIBERNIA GBS PRODUCTION PLATFORM
SIZE COMPARISON


Sea Level
CABOT PLACE
HIBERNIA GBS PRODUCTION PLATFORM
STATFJORD "A" PRODUCTION PLATFORM NORTH SEA

C3582F

MONOHULL PRODUCTION STORAGE VESSEL

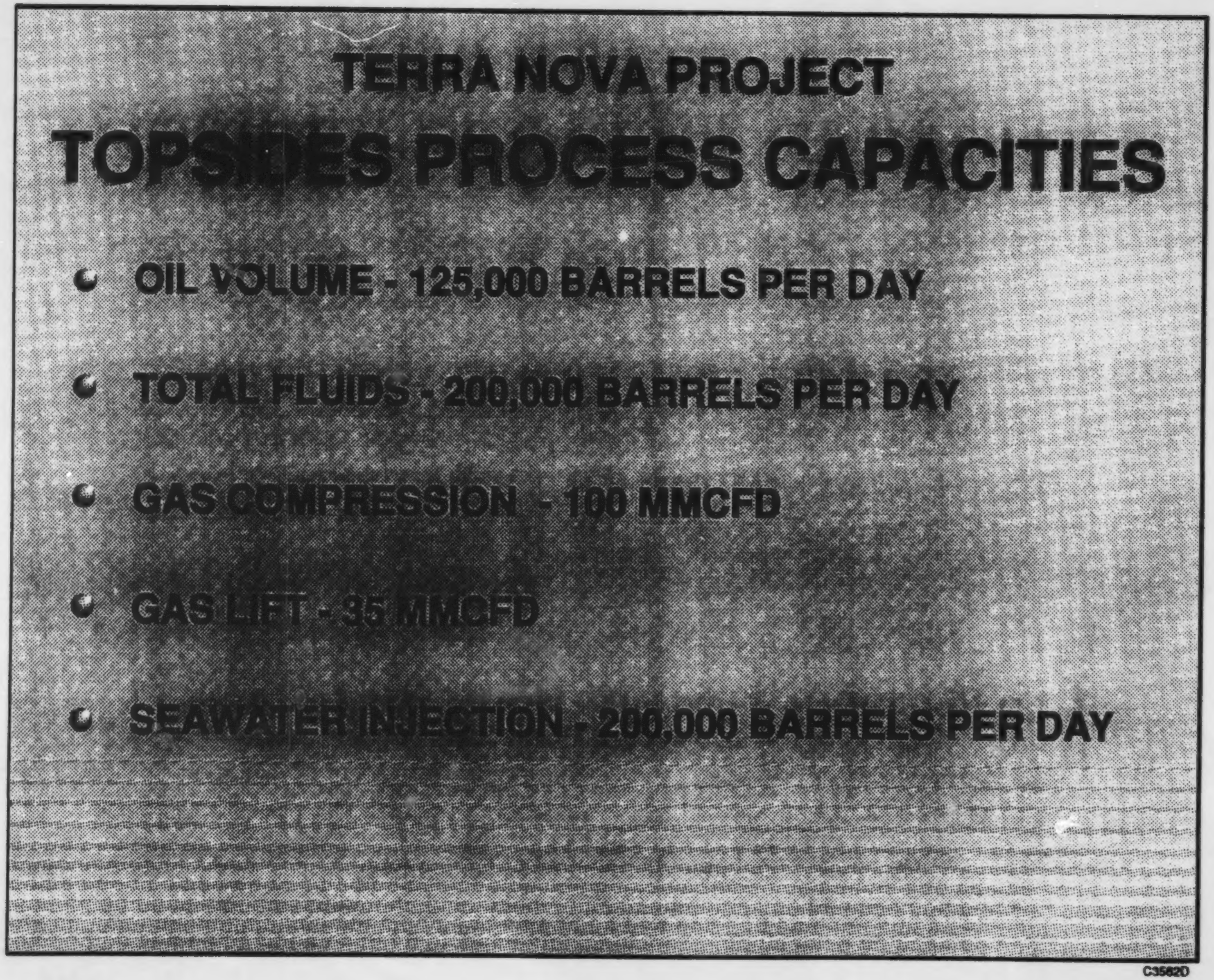


C3562B

TERRA NOVA PROJECT
VESSEL DESCRIPTION

- MONOHULL PRODUCTION AND STORAGE VESSEL
- DIMENSIONS
  - LENGTH 800 FEET
  - BEAM 140 FEET
- DISPLACEMENT
  - 120,000 DWT
- STORAGE CAPACITY - 650,000 BARRELS
- TURRET-MOORED WITH THRUSTER ASSIST
- QUICK-DISCONNECT/RECONNECT CAPABILITY

C3562C



TERRA NOVA PROJECT

TOPSIDES PROCESS CAPACITIES

- OIL VOLUME - 125,000 BARRELS PER DAY
- TOTAL FLUIDS - 200,000 BARRELS PER DAY
- GAS COMPRESSION - 100 MMCFD
- GAS LIFT - 35 MMCFD
- SEAWATER INJECTION - 200,000 BARRELS PER DAY

C3562D

TERRA NOVA PROJECT

TANKERS AND SUPPORT VESSELS

- SHUTTLE TANKERS
  - UP TO THREE
  - 100K - 120K DWT
  - DOUBLE HULLED
  - ICE CLASSIFICATION
- SEMI-SUBMERSIBLE RIG - DRILLING/WORKOVER
- MULTI-PURPOSE VESSEL - SUBSEA INTERVENTION
  - WILL CARRY FIREFIGHTING CAPABILITY
  - SUBSEA DESIGNED FOR ROV INTERVENTION
- SUPPLY BOATS
  - RESUPPLY
  - ICEBERG MANAGEMENT
  - ANCHOR HANDLING
- STANDBY VESSEL

C3562E

EAST COAST
OFFSHORE OIL DEVELOPMENT
BENEFITS

- REDUCE RELIANCE ON LIGHT CRUDE IMPORTS
- IMPACT ON BALANCE OF PAYMENTS
- DEMAND FOR DOMESTIC GOODS AND SERVICES
- EMPLOYMENT
- BUSINESS OPPORTUNITIES
- TECHNOLOGICAL KNOWLEDGE
- REVENUES TO GOVERNMENTS

C3582H

SPEAKER : **TORBJORN MEHLI**

COMPANY : **AKER** a.s.

LOCATION: **OSLO, NORWAY**

TOPIC : **A NEW GENERATION OF FLOATING PRODUCTION FACILITIES**

BIOGRAPHY: Torbjorn Mehli, 42 years old, is a Project Director for the Marketing and Technology Division in Aker A.S. He is responsible for integrated product development for floaters in Aker. His duties also include preparation of integrated activities where engineering, procurement, and construction are in one contract.

Mr. Mehli graduated from the Norwegian Institute of Technology in 1974 as a Naval Architect and Marine Engineer. His early experience includes design and operation of merchant ships. He was Marine Superintendent for the operation of 10 dry cargo vessels for European trade.

He joined Aker Engineering in 1984. His work was dedicated to floating production systems. He was Project Manager for product development, concept studies, and preliminary engineering.

A NEW GENERATION OF FLOATING PRODUCTION FACILITIES

By

Torbjørn Mehli

Aker a.s.

1. INTRODUCTION

The objective of this paper is to give a brief presentation on a new generation of catenary anchored floating production facilities (FPF). The presentation will focus on two designs, both proposed with modularized topside facilities:

- Aker PM production modularized semi-submersible
- Aker PV turret moored monohull production vessel

These designs are developed by Aker through a comprehensive development program launched last year, and are part of a more "visible" product orientation in Aker for FPF. The objective of this program is to offer cost-effective but tailormade FPFs according to the functional requirements of the Client, if required also as a complete turnkey delivery for a specific location. Aker have during the past 18 months spent considerable resources on documentation and external verification of these two designs.

2. GENERAL

The floaters developed under this program are primarily designed for safe operation throughout a complete field life in rough environmental areas like the North Sea.

These designs are developed according to the requirements of the Norwegian Petroleum Directorate (NPD). As part of the verification of the designs, it is natural for us to use the verification procedures prepared by the classification societies. The designs are documented in such detail that main scantling approval for the hull and the marine systems has been given.

The marine environmental conditions offshore Canada and Norway have much in common. The wind and waves recorded off the East coast of Canada are to a large degree similar to those experienced off the Norwegian coast, north of the 62nd parallell. In terms of ice accumulation on structures generated by seaspray, this is accounted for in the designs. Winterization for personnel, equipment and piping protection is required, however, a complete closing of all working areas is normally not necessary.

Icebergs do not occur in Norwegian waters presently developed by oil companies in Norway. For floaters, the ultimate way of iceberg protection is quick disconnect systems for risers and mooring lines which may easily be incorporated. Ice reinforcement for sheet ice is in general not required, but may also be incorporated at a reasonable cost, in particular for concrete substructures.

It should also be mentioned that preliminary engineering for Petro-Canada on the Terra Nova field was carried out in 88/89 by the joint venture company SNC/Aker Offshore Inc and BFL Consultants Ltd. This engineering was based on one semi-submersible and one monohull concept.

3. TECHNOLOGICAL TRENDS FOR FLOATING PRODUCTION FACILITIES.

Focus on topside.

The more complex part of a floating production unit are the topside facilities. Long lead items are included in many of the topside systems, which also have bearing on the engineering and procurement activities. Comparing the topside facilities and the hull, the complexity of the hull is normally less, as long as the basic marine requirements (floatability, stability, mooring and motion) are fullfilled. The optimum approach accordingly is to develop the topside design in sufficient detail, and then proceed with the design for a suitable support structure, with the required characteristics to support the selected topside facilities.

This approach can be called the "top-down" design philosophy, which is the procedure Aker have followed for this new generation of floaters.

Flexibility

Another trend we have noticed is the requirement for flexibility. Flexibility is important from the initial design through fabrication and production until the field is fully depleted and the platform removed. The floater itself has the inherent flexibility for easy installation and removal compared to fixed platforms.

From the North Sea, frequent and comprehensive changes to the topside have been seen during the production period. This is due to factors not foreseen at the design stage; for instance tie-in of other reservoirs, increased system capacities etc.

4. DESIGN PHILOSOPHY

In terms of topside design philosophy, there are basically two alternatives for the floaters:

- integrated
- modularized.

The integrated approach gives a topside with reduced weights compared to topsides with modules. Integrated decks are suitable for platforms where the expected production characteristics are reasonably well known to the operator over the field life. We have concluded that the extra carrying capacity required for a modular topside is a limited penalty for flexibility.

The modular approach has benefits in the fabrication as well as the production phase. For larger platforms, the Hibernia deck alternative is an attractive solution.

For the fabrication phase, in-door fabrication is easier to achieve for modules. Specialist contractors may be utilised for the various modules. A topside consisting of modules will also give better delivery schedule than an integrated option.

For the production phase, equipment and systems not needed for the initial production may be installed later with obvious advantages in terms of capital expenditure. Furthermore, later changes in functional requirements can easily be accomplished by exchange or modification of modules. This topside flexibility is of particular importance for a floater, where even a utilisation at other locations cannot be ruled out.

The consequence of this philosophy is that limited piping and equipment will be installed in the hull. The hull will mainly be a carrier for the topside facilities. For this reason, the hull part can be designed and fabricated independently of detailed input on major equipment and long lead items. In our opinion, a modular topside approach is often the answer to the topside requirements for flexibility. We have selected modular topsides for both designs.

The Aker PM and Aker PV designs are developed to be fully completed alongside an outfitting quay at the completion yard. Extensive offshore work is thereby limited to hook-up of the mooring and the riser lines, and final commissioning of the hydrocarbon system.

5. THE SEMI-SUBMERSIBLE FLOATER - AKER PM

General

The inherent feature of the semi-submersible is that a certain footprint and waterline area is necessary to fullfill basic marine requirements for stability and motion. This footprint area usually generates sufficient area for the topside facilities without stacking of modules on top of each other. This means that all modules and pancakes are available for lifting at all times, which will ease construction as well as any replacement or repair of modules during the production period.

A truss deck structurefor module support is described here, however, alternative deck structures are possible.

Design basis

The "basic" version of the Aker PM is designed for the following functional requirements:

Max crude oil production : 12 000 SM3/day
Max water production : 3 600 SM3/day
Max gas production : 0.8 Mill SM3/day
Max water injection : 19 200 SM3/day
Total number of risers : 10
Living quarter capacity : 100 persons

Main characteristics

The Aker PM's lower hull is composed of a square base ring pontoon and four stability columns and with passive catenary mooring. The topside facilities are modules and pancakes on top of a truss deck structure. The stability columns provide sufficient intact and damage stability to carry the specified topside weight with ample margins. (ref. fig. 1)

The well fluid is transferred from the subsea wellheads, through flexible risers via connectors fixed to the pontoon. From the connectors, the well fluid piping is arranged as hard pipes on the inner part of the two aft columns to the production manifold on deck.

The process is a single, two stage separation train. The processed crude is exported through the pipeline, and the produced gas is reinjected.

The main characteristics of the Aker PM responding to the above design basis are as follows:

Topside carrying capacity (above truss deck)	:	11 000 tonnes
Length (hull)	:	79.0 m
Breadth (hull)	:	79.0 m
No. of mooring lines	:	12
Operational draft	:	23.5 m
Corresponding displacement	:	35 800 tonnes

Based on the present configuration, the design can be modified to match actual field requirements.

Topside layout

An important objective for the topside layout is the effective separation between safe and hazardous areas.

Altogether 7 modules and pancakes are arranged on deck (ref. fig. 2):

* Living quarter
* Utility module
* Power module
* Water injection module
* Gas compression module
* Separation modules (2)

One crane is arranged on each side of the deck, reaching all required parts of the platform.

The main lifeboat platform is arranged ahead of the living quarter, and the secondary lifeboat platform is arranged aft of the process area. Lay-down areas and infill areas are to be part of the respective modules.

Truss structure

The truss type deck support structure is located in-between the columns, (ref. fig. 3) and the stillwater distance between the sea surface and the lower chord of the truss is 5 meters only. The truss deck has been designed for wave forces as in jacket structures.

The reason for this arrangement is to lower the overall center of gravity which is an important parameter for floaters, and to generate a low topside profile reducing the overall wind effects.

The Aker PM has virtually a large available deck area which can within the specified topside carrying capacity, area limitations and minor adjustments, accommodate virtually any normal module/pancake required for drilling and production.

The Aker PM, with this actual truss deck design, has been tested at the ocean model basin in Trondheim, Norway. This test verified that the positive airgap is 1.4. to the module support deck in an extreme 100 year condition. In a rough operating condition (Hs=6m) corresponding to a North Sea yearly probability of about 7 %, the waves occasionally washed up to the middle of the deck structure.

Aker has also funded an external simulation study on ice accretion on the truss deck structure. The main purpose of this study was to simulate sea spray icing on the Aker PM platform when operating under extreme winter conditions during a 72 hours period at Tromsøflaket north of Norway. It was concluded that the weight of the accumulated ice was 370 tonnes, which is well within the margins of the topside carrying capacity for the Aker PM.

Hull altenatives

Two alternative designs for the hull structure have been developed:

- Steel structure
- Concrete

For both versions, the systems and mechanical components installed in the hull are limited to the marine systems.

Steel hull version:

The Aker PM steel structural design is based on the experience gained through the Aker semi-submersible drilling rigs, where Aker today have designed approximately 20 % of the world fleet, and from the design of the Snorre TLP. Through a tight cooperation with the Aker yards, we have been able to improve the structural design. The pontoons and columns consist of mainly circular elements with larger shell thicknesses and ring frames only. This approach reduces the welding operations and associated man-hour cost considerably.

Concrete hull version:

Through the Aker company Norwegian Contractors, an Aker PM design with concrete hull, but otherwise with an identical deck and topside has been developed.

Concrete for offshore platforms has proven to be a a very efficient material in terms of large, fixed Gravity Base Structures. More than 20 such structures are installed in the North Sea. However, it is also an efficient material for floaters, and the first concrete floater will be the Heidrun TLP to be installed offshore Norway in 1995.

The concrete version of the Aker PM features the same hull configuration as the one in steel. The concrete material used is LWA 60. Much efforts have been put into the effective use of concrete for a small scale floater. The main particulars for the concrete version are marginally larger than the steel version. The displacement of the concrete version is about 16 % more. Concrete is accordingly a very interesting hull material alternative.

The columns are constructed based on slipforming techniques, whereas the pontoon circular crossection requires special formwork. A very attractive hull fabrication schedule can be offered, as the construction time from start in dry dock is only 9 months. The main particulars for the concrete hull are shown in the table below:

Topside carrying capacity (above truss deck)	:	11 000 tonnes
Length	:	80.2 m
Breadth	:	80.2 m
Number of mooring lines	:	12
Operational draft	:	25.0 m
Corresponding displacement:		41 600 tonnes

In terms of fabrication, the concrete substructure will be completed to the top of columns before tow-out and mating of hull and deck structure. The deck structure arrives mounted on a barge and will be mated to the hull in a similar mating operation as for the GBS/topside platforms. After mating, the hull structure with the mated deck will be towed to the module assembly site.

6. THE MONOHULL - AKER PV

Design basis

The Aker PV is designed according to the same design basis as for the Aker PM described in section 5.

Main characteristics

The Aker PV is a turret-moored, monohull production vessel with thruster assistance for station-keeping. The topside facilities consist of production modules and pancakes arranged on a separate module deck above the storage tank deck. (ref. fig 4)

The well fluid is transferred from the subsea wells through the flexible risers, choked at the turret deck and transferred from the turret to the processing deck via a jumper hose system. An alternative swivel system can be arranged.

The selected processing facilities comprise separation, gas compression and water injection facilities. The process is a single, two-stage separation train. The processed crude is distributed to the storage tanks via a manifold system. The produced gas is recompressed and used for fuel gas and reservoir reinjection.

Three deck cranes, covering modules and pancakes are provided. A complete crude offloading system is arranged at the stern of the vessel.

The main characteristics for the Aker PV are as follows:

Topside carrying capacity (min)	:	11 000 tonnes
Length	:	235.0 m
Breadth	:	37.0 m
Depth	:	20.0 m
Draft (max)	:	12.0 m
Storage capacity	:	66 000 m3

Based on the present configuration, the Aker PV can be modified according to actual field data, topside requirements and storage capacity.

Topside layout

The basic layout is based on a safety philosophy which requires separation of safe and hazardous areas.(ref fig 5) Another significant topside layout impact is the location of the turret, around which the vessel will weathervane, depending on prevailing winds and currents.

Much efforts have been used in coming to a decision about the turret location. The ultimate aim is of course to achieve a natural weathervaning stability for the vessel. To determine the optimum position of the turret, Aker has carried out a comprehensive wind tunnel test at the Norwgian Institute of Technology. It was concluded that the optimum position of the turret was at 1/3 of the total length from the bow. A position further aft would reduce this stability, and also increase the thruster power required to maintain a stable direction.

The module deck is located approx. 3.5 m above the tank deck to achieve access to the storage tanks, and to separate the storage tanks and the modules. Firewalls are erected forward and aft of the turret. A sheltered walkway connects the forward and the aft part of the vessel.

From the bow and aftwards, the topside installations are arranged as follows:

- Living quarter/main control room/helideck
- Water injection/workshops
- Turret/risers/mooring winches
- Separation and gas treatment
- Utilities
- Main power
- Ground flare, metering and offloading

The main dimensions are mainly given by the requirements to the crude oil storage capacity. For this reason, there is within present dimensions ample space for increased topside facilities.

Hull design

The hull is the support structure for the topside, and the storage volume for the produced oil. The hull oil storage is protected with double bottom and wing tanks for clean ballast in the entire length of the vessel. A damage to the outer skin will therfore have no pollution effect. The midship section of the vessel is shown in fig. 6.

There are other hydrodynamical requirements to a stationary, moored vessel than to a conventional merchant vessel. For a vessel of this size, the sheer length is sufficient to provide acceptable heave and pitch motions with regards to processing and human comfort.

An import parameter for merchant vessel is the aftship design to create best possible inlet conditions to the propeller. For a stationary vessel, this parameter will be of little significance. Accordingly, the aftship of the Aker PV resembles the aftship of a barge. The forebody of the vessel has great resemblance to a conventional tanker of the same size.

In general, the Aker PV hull is designed for easy fabrication. There is a double chine along the full length of the vessel, which will also have a damping effect on roll motions. The hull can be assembled in a suitable dry-dock or on a building berth. The preferred mode is a one piece assembly of the total structure prior to launching. Alternatively the hull can be assembled in two or more pieces, launched and joined afloat using a welding caisson.

After launching and outfitting, the hull is towed to the assembly yard for lift installation of the modules and the overall completion of the vessel.

7. THE TURRET

General

The turret is a critical area for a successful design and operation of a monohull production vessel. The turret supports the mooring lines and the riser system, and allows the vessel to weathervane relative to the turret on a bearing system. The turret is cylindrical and provided with a top deck for support of equipment. Ref fig. 7.

The following systems are incorporated at the turret:

- mooring winches and fairleads system
- flexible riser connector system
- production and injection manifold system
- chemical injection system
- subsea control system
- turret/hull transfer system
- turret bearing system

The production vessel is moored to the seabed by 9 mooring lines.

The riser connectors are arranged along the turret periphery in groups in between the mooring lines. Each riser is led through a vertical guide pipe, and the well-fluid from each riser is transferred to the manifold at the turret deck. The turret is designed for hook-up of up to 15 risers. Subsea control umbilicals are strapped to the riser lines and integrated in the connector system.

Transfer system

The turret to hull transfer system is designed for continuous flow. It consists of two sets of jumper lines. In operation, one set is connected and operating while the other can be jumped and tested to be ready for the vessel rotation. Hose jumping is carried out by means of trolleys running on circular rails at the connector station support structure above the turret.

An alternative to the jumper system is a swivel system in the center of the turret.

The turret bearing system comprises vertical rollers and horizontal thrust rollers running on circular rails. The vertical roller bearing system consists of a continuous chain of rollers.

8. FABRICATION STRATEGY

Constructability and fabrication aspects are given high priority for the two designs. Aker's fabrication yards have been involved in the design development from the start of the project.

The fabrication of the floaters presented can be executed applying at least two alternative contract strategies:

* One fabricator building all hardware elements, hull and topside modules.

* Hardware elements being fabricated at specialist fabricators where the strength of the individual fabricator can be utilized.

The selection of the fabrication strategy depends on the Client's requirements for national content, delivery schedule, available contractors and their relevant capabilities/capacities. The fabrication sequence is shown in fig. 8. The liftinstallation of modules and pancakes for the Aker PV will be similar.

It may prove difficult to find a fabricator who effectively can fabricate all hardware elements. The more flexible fabrication strategy is accordingly to fabricate the hull separately and arrange the topside facilities in modules/pancakes which can be fabricated by specialist fabricators. One fabricator must also be selected for assembly of all hardware elements. The Aker production units are designed to be fully completed alongside an outfitting quay at the assembly yard.

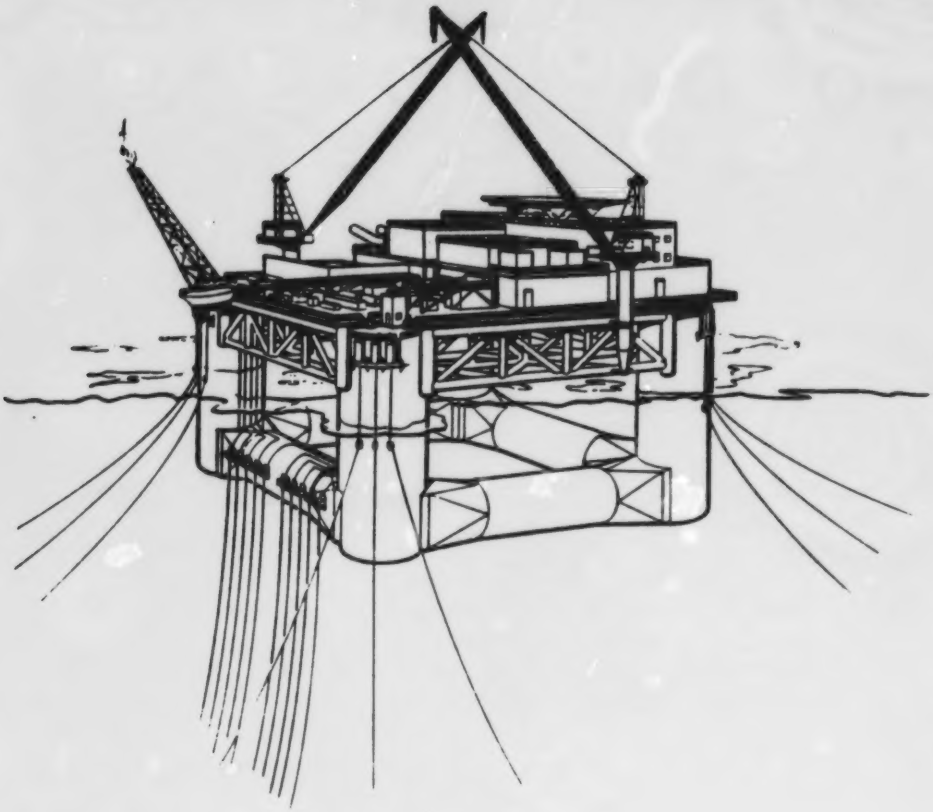


FIG. 1

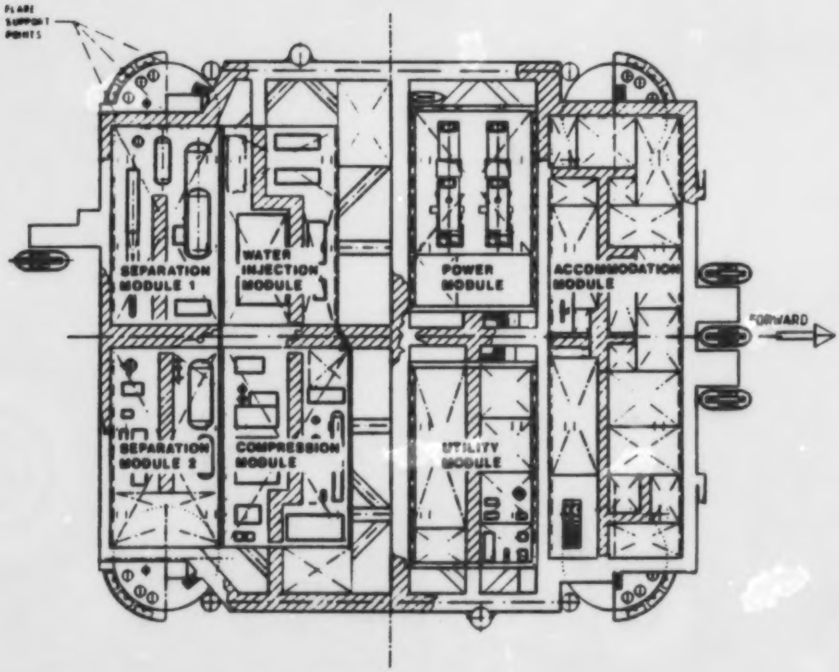

FLARE SUPPORT POINTS
SEPARATION MODULE 1
WATER INJECTION MODULE
POWER MODULE
ACCOMMODATION MODULE
FORWARD
SEPARATION MODULE 2
COMPRESSION MODULE
UTILITY MODULE

FIG. 2

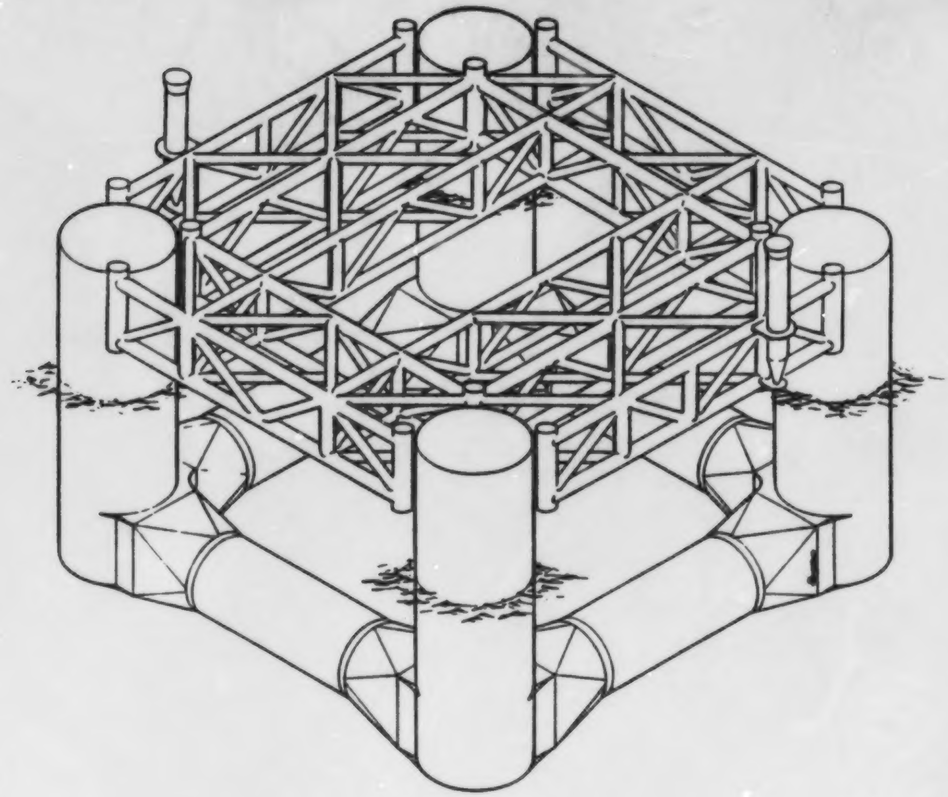


FIG. 3

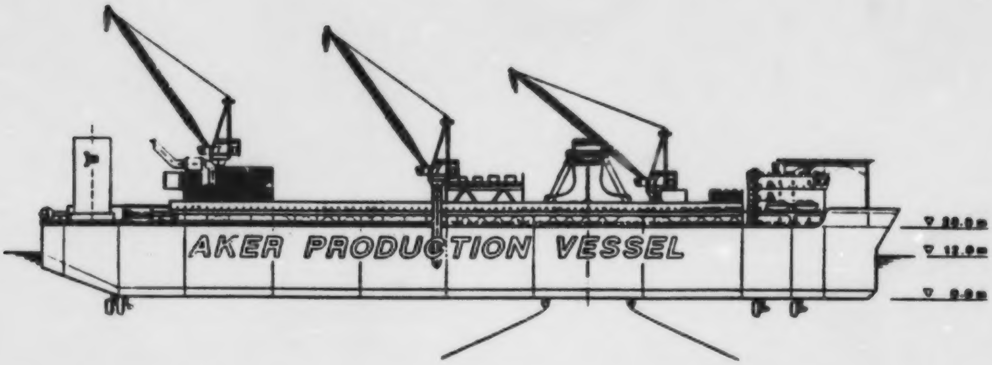

AKER PRODUCTION VESSEL
▽ 20.0 m
▽ 12.0 m
▽ 0.0 m

FIG. 4

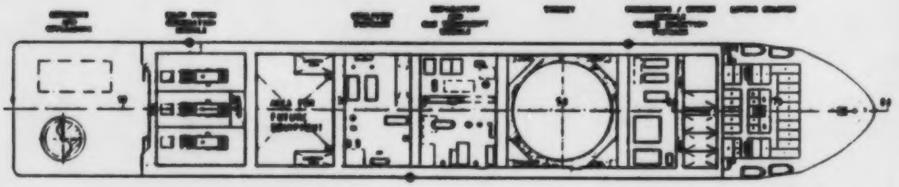


FIG. 5

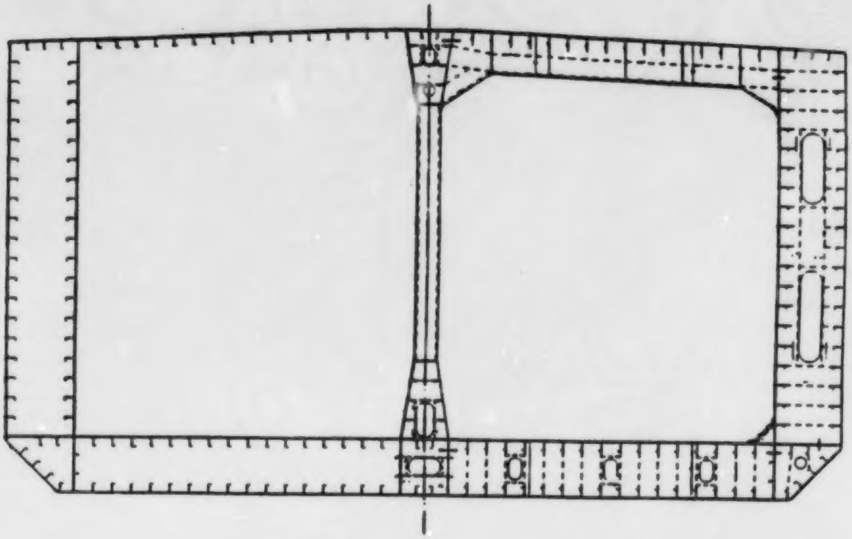


FIG. 6

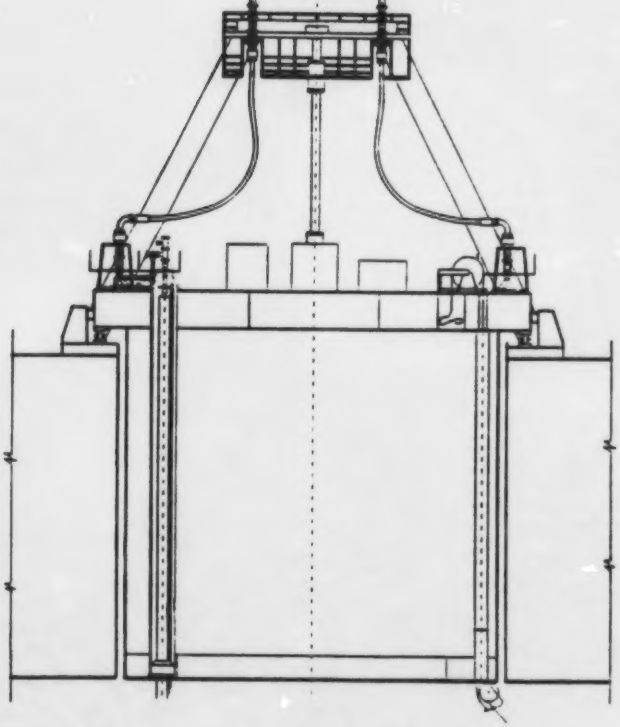


FIG. 7

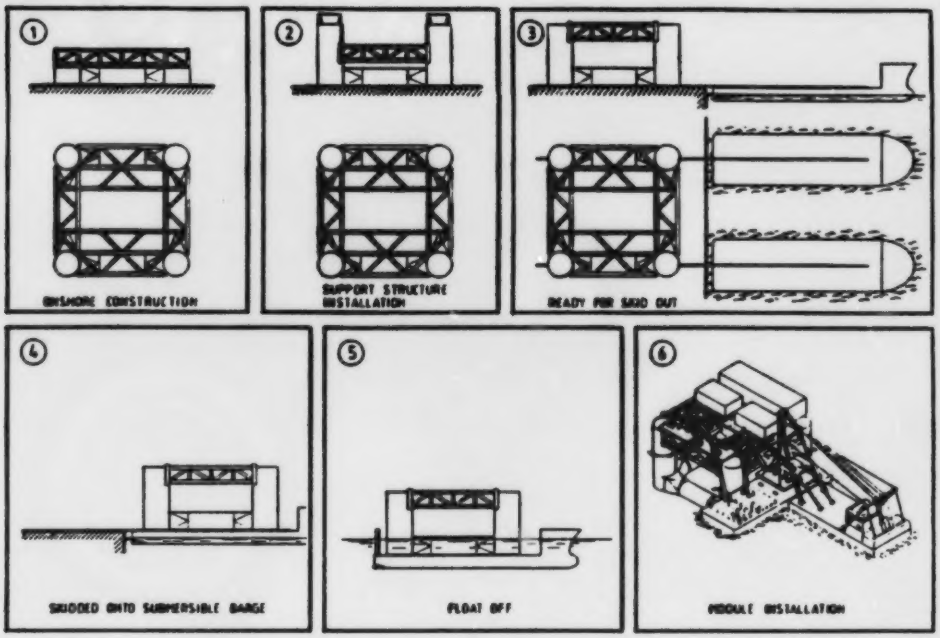

①
ONSHORE CONSTRUCTION
②
SUPPORT STRUCTURE INSTALLATION
③
READY FOR SKID OUT
④
SKIDDED ONTO SUBMERSIBLE BARGE
⑤
FLOAT OFF
⑥
MODULE INSTALLATION

FIG. 8

SPEAKER : ***MURRAY H. CHANCELLOR***

COMPANY : ***J.P. KENNY OFFSHORE ENGINEERING (CANADA) LIMITED***

LOCATION: ***ST. JOHN'S, NEWFOUNDLAND***

TOPIC : ***SUBSEA PRODUCTION SYSTEMS;***
PAST, PRESENT & OFFSHORE NEWFOUNDLAND;
CAN ENGINEERING REDUCE COSTS?

BIOGRAPHY: *Murray Chancellor was educated in Sydney, Australia, graduating from the University of New South Wales with a Bachelor of Engineering (Civil) in 1976. He is a Chartered Engineer registered with the British Council of Engineering Institutions. He has approximately fifteen years experience, primarily in design and construction of marine pipelines and subsea production systems.*

He is currently Vice President of JP Kenny Offshore Engineering (Canada) Limited and responsible for the development and execution of all projects handled by the Company in Canada and in Joint Venture with RDS Engineering.

Having joined the JP Kenny Group early in 1983, he was initially Operations Manager in the Aberdeen office for five years and subsequently in Sydney, Australia for approximately three years prior to moving to St. John's.

Before joining JP Kenny, Murray worked on design and construction of marine pipeline projects in the North Sea and the Middle East.

SUBSEA PRODUCTION SYSTEMS

PAST, PRESENT AND OFFSHORE NEWFOUNDLAND.

CAN ENGINEERING REDUCE COSTS ?

by

M. H. Chancellor
Vice President, J P KENNY Offshore Engineering (Canada) Ltd.

D. A. Phillips
Manager: Company Development, J P KENNY & Partners Ltd., London

Table of Contents

1.0 ABSTRACT

2.0 REVIEW OF SUBSEA PRODUCTION SYSTEMS

- 2.1 Main Features and Modes of Operation
- 2.2 Current Technology Trends

3.0 CAN ENGINEERING REDUCE COSTS?

- 3.1 Overview of Pipeline Engineering
- 3.2 Fitness for Purpose Design Methodology
- 3.3 Coatings
- 3.4 Trenching/Rock Dumping

4.0 CONCLUSIONS

1.0 ABSTRACT

In water depths comparable with offshore Newfoundland, subsea production systems around the world have evolved through various stages of development. This evolution has occurred in response to a number of factors such as costs of alternative conventional systems, design and operational experience, confidence and reliability of subsea components. The first part of this paper presents a review of subsea production systems, including their main features and modes of operation and how these have changed with time in response to various influencing factors.

Current technology trends in subsea and floating production systems are described with particular reference to relevant factors for future development offshore Newfoundland. Current practices in the industry, particularly in the North Sea, are described, indicating the trends which are influencing the direction of subsea production systems.

The last part of the paper presents a summary of the major cost components of current subsea systems. This summary indicates that material and construction costs for pipelines and risers form the major cost component of most subsea production systems. Generally, these costs tend to increase as a proportion of total development costs as the complexity of the subsea facilities is reduced. This indicates that a more imaginative approach is required to the engineering of pipelines and risers in order to enhance overall project development economics. In this context, the paper examines the traditional approach to pipeline engineering and compares this with a fitness for purpose design methodology for subsea production systems.

2.0 REVIEW OF SUBSEA PRODUCTION SYSTEMS

The technology utilized in subsea and floating production systems has changed and continues to change in response to the ever increasing demands of a sophisticated industry. This section initially presents a summary of the different configurations of subsea production systems from single satellite wells through to separate subsea field developments. For the purposes of definition, the range of configurations are presented and a brief review of the main component parts of subsea/floating production systems are described. Trends in technology development within subsea systems are discussed in general terms and some specific areas of development are described as examples of the type of development currently underway.

2.1 Main Features and Modes of Operation

The configuration of subsea production systems is driven by a wide range of factors. However, in general the following two variables provide a major influence in determining the overall system concept:

- Number of wells
- Distance to, and availability of host facilities and transportation infrastructure

Primarily, the number of wells and their location requirements from a reservoir viewpoint will greatly influence the system layout. However the potential for directional drilling from a host facility will determine the overall requirement for subsea completions. This dependence on host facilities does therefore greatly influence the system layout and in cases where a host facility is not available, may lead to the selection of a Floating Production Vessel (FPV).

In summary, subsea production systems may be categorized by the following examples. Typical layouts of some of these categories are shown in Figures 2.1 to 2.4.

- Single satellite wells tied to existing platforms
- Multi-well system tied to host platform
- Separate field subsea systems tied to host platform
- Subsea system exporting directly to shore

- Separate field subsea system supported by Floating Production Vessel (FPV)

- SWOPS concept (ie Shared FPV)

In general, all of these systems share the following major components. Although these components will vary from system to system, the principles of their operation are essentially common.

- The production system (production/test/water injection/gas lift)
    - Production
    - Well test
    - Water or gas injection
    - Gas lift
    - Chemical injection

- Wellhead protection

- The control system
    - Data acquisition
    - Function control

- The pipeline and riser system
    - Pipelines
    - Umbilicals
    - Riser systems (Hard pipe, flexible, turret)

2.2 Current Technology Trends

"Necessity is the Mother of Invention". Technology for subsea and floating production has developed and continues to change in the continual search for technically superior and more cost effective solutions for oil and gas production. The imagination and creativity applied to engineering of subsea oil and gas production, in the past and in current development work, equals any creative achievements of mankind. We could imagine every oil company's "ultimate" oil production facility consisting of a subsea, maintenance free, remotely operated (unmanned) system, capable of pumping combined produced oil/gas to an onshore receiving and processing facility. Since the first subsea oil production systems in the North Sea from the Argyll Field and then the Cormorant Underwater Manifold Centre (UMC), the methods and modes of operation have changed markedly in response to the changing environment of the industry.

For example, the Cormorant UMC installed in 1982, provided the initial testing ground for a sophisticated subsea production system tied back to a fixed platform. Today, the UMC could be considered an over sophisticated system designed when the oil price looked set for continuous growth and at a time when there was little operating experience of such systems. In retrospect, much of the technology has been superseded or proven inadequate. Technically, some aspects of the design, whilst proving adequate, have not been met with enthusiasm within the industry on subsequent projects. Through Flow Line (TFL) maintenance has been used in the Gulf of Mexico and was provided on the UMC but has not been widely used since in the North Sea. This is not to say that it will not be further developed in the future. The maintenance vehicle originally installed for the UMC has now been removed with maintenance being performed by a free swimming ROV. ROV's have been established as an integral part of subsea developments whereas manned submersibles have largely been dispensed with for this application.

The multiplexed electro-hydraulic control system first used on the UMC has proved very successful. Initial industry reluctance to accept such a complex system in a subsea environment has now been overcome and electro-hydraulic systems have proved to be as reliable as the alternative, less complex systems.

The Balmoral Field proved a benchmark for Floating Production Systems in terms of use of all flexible risers in place of hard pipe, steel risers.

Welding and metallurgy has developed greatly permitting use of exotic coatings and alloy steels such as inconel cladding for fluids rich in hydrogen sulphide and carbon dioxide.

The above few examples demonstrate how industry experience together with the continual search for more cost effective solutions lead to the evolution process for subsea and floating production systems. Literally hundreds of individual systems within an overall facility are subject to review and potential change from project to project as previous experience or variations in the site specific conditions of a new project drive a need for new project requirements.

Several areas which are currently under review and which have the potential to offer significant changes in future design philosophy for subsea and floating production systems are discussed briefly below. These developments are largely being pursued independently of each other by individual organizations or joint industry participation. This splintered approach to development may not result in the single "ultimate" oil production facility. Nevertheless, as these individual development areas are being driven by technical and commercial motives, they are all contributing to the general movement and development within the industry. By way of example, a number of areas of development which are currently being pursued are listed below. The list does not cover all areas of development currently being pursued, but is intended to cover some of the more pertinent aspects.

- Developed to Prototype Stage or Beyond

    Diverless Technology
    Subsea Separation
    Multiphase Metering
    Multi-phase Pumping
    Subsea Wirelining
    Subsea Production in Ice Prone Areas
    Subsea Leak Detection
    Subsea Chemical Injection and Storage
    Through Flow Line (TFL) Well Servicing
    Acoustic Control Systems
    Deep Subsea Deployment of Heavy Modules

- Concepts Being Developed

    Fluidic Choke Valves
    Fibre Optic Data and Control Transmission
    Subsea Power Generation
    Modular Expandable Production Systems

In order to further demonstrate the trends in development of subsea technology, a few of the above areas are described in more detail below.

Diverless Technology

This area of development is almost a generic term which encompasses a large number of individual development areas. Nevertheless, in general terms, as the oil reserves in the shallow continental shelf areas of the world are further exploited the trend towards deep-water exploration and production will increase, increasing the need for diverless technology. In the North Sea almost all installations are within saturation diver depth, the exception being in the Norwegian Trench, hence the need to develop diverless techniques has not received the urgent attention it might otherwise have. In other areas of the world, including Brazil and the Gulf of Mexico where the exploitation of deep-water reserves is underway, diverless technology is subject to much more development.

Diverless technology has been experimented with for some years, however, in the North Sea it has generally been as a primary system with a diver back-up. This type of experimental technology is essential to the development of reliable systems if they are to be deployed in depths where diver intervention is impossible.

In the North Sea it is debatable if there is a need for diverless technology, however, certain operations are regularly undertaken by ROV which previously were diver operations. The combination of ROV, and underwater video cameras have more or less replaced divers for visual inspection purposes. Similarly valve override systems are designed for ROV override rather than diver operation. As this technology develops, the experience and confidence gained is essential before the technology is applied in depths where diver intervention is not an option.

Subsea Separation

Subsea separation is an example of technology that is being used in production at present although there are number of projects in various stages of development looking to improve the technology. Subsea separation offers a number of practical advantages to subsea or floating production systems:

- Slug catching capability for pipelines prior to fluids entering riser systems.
- Separate multi-phases for ease of pumping.
- Reduce water cut in produced fluids to reduce corrosion potential and/or to reduce volume of produced fluids requiring processing.

The Highlander slug catcher is installed at the base of the Tartan 'A' platform and is connected to the 12-inch bulk crude and 8-inch test pipelines form the Highlander subsea template. It is primarily to reduce slugging effects on the riser on Tartan 'A' and to assist with pumping fluids to the surface.

The Argyll subsea separator was installed on a trial basis in June 1988 adjacent to the base manifold below the Argyll Floating Production Vessel (FPV). The separator, developed by BOET is intended to separate out the almost 80% water cut from one particular well prior to the fluid reaching the manifold. The trial unit on Argyll is a scaled down version of the full scale unit which comprises a 2-stage separator, oil storage for tanker loading from a buoy and gas disposal through a flare buoy. The main purpose of this unit is to remove the majority of the produced water prior to the fluid being received on the topsides hence reducing the loading on the topsides process facilities.

The Goodfellow Associates Subsea Production Systems (GASP) has recently successfully completed prototype testing at the Tees Offshore Base. The system is an ambitious program combining subsea separation of oil, gas and water along with well testing facility using a multiphase meter and fiscal metering of the separated oil and gas. No specific field has been identified for installing the GASP system, however the technology, when fully developed can be applied to a specific field with specific fluid composition and throughput.

Over the last few years a number of studies have been undertaken by various organizations into the problems and design of subsea separators. Patents have been taken out covering the most probable configurations, including vertical separators drilled into the seabed and subsea versions of the hydrocyclone separator. Most of the technology has been proven on surface, although only field experience will encourage confidence and full exploitation subsea. Subsea separation is likely to play an ever increasing role in offshore satellite field development.

Multiphase Metering

As with the subsea separators, multiphase metering will play an increasing role in the future development of satellite fields. The first stage of development currently underway will produce meters with an accuracy sufficient for well testing purposes. Eventually meters with an accuracy suitable for fiscal metering purposes will be developed.

The inclusion of an effective subsea test meter can result in substantial savings by removing the need for a test flowline. Furthermore, topsides equipment such as test separator and risers are no longer needed hence the topside weight savings could be crucial to a project, particularly where the host platform is already in existence and has limited extra capacity or space is limited on an FPV.

The basic problem facing any multiphase metering system is that it has to make at least three, and possibly five measurements; the mass or volume flowrates of the individual components, or the velocities of the individual phases and the phase volume fraction of each individual phase. Pressure and temperature also have to be determined and the PVT behaviour of the multiphase mixture must be known. Two different routes to solve the problem are being followed, one is based on the use of separation whilst the other more advanced technique is to employ several devices in one unit to establish the constituents of the multiphase flow, (Direct measurement method).

Separation based systems usually involve the continuous sampling of a fraction of the flow which is separated into its constituent phases each of which is metered using single phase techniques. No system to date attempts to separate the two liquid phases of oil and water but depend on liquid density measurements to establish the percentage of oil and water.

Several research projects are currently under way into direct measurement techniques of metering. The information available is limited due mainly to commercial considerations. Knowledge from the nuclear industry is being used to develop a system using neutron-based techniques for measuring phase compositions and velocity. Several joint industry groups are investigating this principle of operation. Although research is progressing, to date no satisfactory systems have become available. The systems under development seem to be concentrating on metering of oil streams with associated gas rather than gas with associated liquids. Future development is likely to be directed towards increasing accuracy to fiscal standards from accuracy acceptable for reservoir management. Direct measurement techniques will most likely fill this requirement.

Multiphase Pumping

This area has attracted a great deal of industry and developmental attention in recent years. However, because of the high level of capital investment and specialist expertise required, the development effort has been concentrated on a few highly funded R & D programs.

Of the various projects presently under way only two, Weir Pumps and Multiphase Systems are pure pump development projects, others such as Poseidon and SMUBS, (Shell Multiphase Underwater Booster Station) are larger projects with pumping playing a role within the project.

All these developments have been driven by the need to reduce costs by extending offshore satellite production technology to encompass fields up to 50 km from existing infrastructure. It is clear that the ability to add energy to an untreated wellstream would be an important contribution to achieving this target. The operating requirements for an oilfield multiphase pump produces a daunting design challenge. The pump may be pumping 100% liquid at one point then being required to pump 100% gas immediately afterwards, this cycle being repeated constantly. On top of this there may be an abrasive sand content in the fluid, then there is the problem of packaging it for use subsea and achieving a reliability acceptable to an operating company.

Poseidon is aimed at developing a fully integrated, self contained, subsea production and transportation concept which could bring oil and gas ashore without any assisting surface facility. Efforts have been concentrated on developing and testing the pumps required to maintain wellhead pressure over a distance. Two different pump concepts have been tested over a period, a twin screw pump and a rotodynamic pump, each of which seems to offer advantages at the differing extremes of gas/liquid compositions.

The SMUBS project incorporates a helico-axial booster and hydraulic turbine driver package. Development work is continuing to produce an electrically driven version of this pump and also the use of contra-rotating impellers to increase the unit's efficiency in high gas fraction fluids.

Weir Pumps multiphase pump development is probably the most advanced project with backing from most major oil companies. However, this project is still considered to be in development stage and is not as yet a commercial project. Prototype testing of the pump is currently on-going. The basic concept of the pump is established and current testing is aimed at refining details and optimizing materials. It is estimated that a surface version of the pump may be ready within a year and the subsea version following some years later.

The Multiphase Systems PLC project has developed a positive displacement pump which will pump all product mixtures from pure oil to oily gas. Surface versions of the pump have been in operation in Malaysia and in the North Sea. The pump is currently ready for deployment in a dry environment although deployment as a wet module would require further development.

Subsea Wirelining

The costs, safety and complexity of performing downhole service operations on subsea completed wells are major concerns of offshore operators. Service costs in particular often become the deciding factor when determining the feasibility of developing small subsea fields. Of particular interest are slickline and conductor line operations. In the past, these operations were usually performed on subsea wells using a semi-submersible rig and rigid riser. However, the development of subsea wirelining units has provided a much less costly method of wireline intervention and allows a complete range of slickline and electric line downhole operations to be carried out on subsea wells from relatively small, dynamically positioned vessels.

The use of a drilling rig with a conventional BOP stack and a tensioned tie-back riser has a number of significant drawbacks when used for well servicing. Transit speeds are slow, anchor handling operations are time consuming and support vessels are required. Hence the overall cost is high and has precluded all but the essential work required to maintain production. Consequently, the procurement of reservoir data has generally not been attempted unless it could be combined with infrequent mechanical work on the well. The expansion in subsea developments has created a need for a cost effective, self contained, well service system which can be rapidly mobilized to carry out a wide range of well intervention tasks. Estimated savings in the region of £500,000 were made on each well service operation in the Argyll Field by using the DSV British Argyll and a subsea wireline system rather than a traditional drilling rig and surface wireline unit.

The development of subsea wireline systems has been on-gong for some 20 years. In 1970, joint trials were carried out by BP, Total and others using a Flopetrol designed subsea wireline lubricator which was deployed in the Zakum field offshore Abu Dhabi in 65 feet of water. In 1984 a similar unit was first deployed commercially in the much harsher environment of the North Sea by Hamilton Brothers on the Argyll field. Subsequently a similar system was developed by BP for use on the Buchan satellite well and later on Magnus subsea wells. The system was developed in conjunction with a DSV operator and a wireline company. The next operational unit in the North Sea was commissioned by Sun Oil for use on the Balmoral field, again the design was undertaken in conjunction with DSV operation and a wireline company.

Today the subsea wireline business is dominated by companies such as Stena with specialized vessels such as the Stena Seawell and the Stena Seaway with the wireline equipment being part of the vessels equipment. In general, the day rates for vessels such as the Stena Seawell are higher than the rates for a semi-submersible drill rig. However, the speed of mobilization and the shorter timescale required for the job makes the subsea wireline option a cost effective solution.

Subsea Production in Ice Prone Areas

Areas of the seas subject to ice conditions experience two distinct ice phenomena. Firstly, areas which freeze solid for a period of the year and suffer from ice crush, and secondly, areas which are subject to iceberg drift over a certain part of the year. Each of these areas requires different technology for development.

In areas of the world where reserves are under frozen seas, the most common technique to date has been to build an artificial island either using gravel or spray ice on which an installation can be deployed and wells drilled. In effect land production techniques are then used. In reality offshore Alaska is the only area of the world where oil is produced under such conditions, although there is great potential offshore Russia. An area of enormous challenge and opportunity for innovative development exists in establishing techniques for subsea production and transport beneath the ice pack. Many of the foregoing development areas will need combining with specialist construction and installation methods to produce a commercially viable system for this application.

In areas where icebergs pose a threat, (e.g. Offshore Newfoundland and Offshore Russia) two techniques are available. In the forum of this conference, we are all well acquainted with the first method being adopted by Hibernia; to build a gravity based structure designed to absorb impact and to deflect the largest anticipated iceberg.

Where a subsea production system is considered, several designs are available which position wellhead and tree components, and manifolding in a recessed caisson assembly such that all production facilities are supported on an artificially lowered seabed, below the maximum depth of iceberg interface. These systems also offer a significantly shorter project schedule to first oil production with associated project cash flow benefits. PetroCanda has tested a prototype caisson on the Grand Banks and other designs have been developed to fabrication level for offshore, east coast of

Russia. It is worth noting that the principles behind these subsea systems make them applicable to utilizing in other areas such as:

- Coastal or shallow water areas.
- Areas subject to high marine vessel activity.
- Arctic locations as described above and including ice formations and ice floes.
- Marine areas of natural beauty or significance.
- Environmentally sensitive areas.

3.0 CAN ENGINEERING REDUCE COSTS?

The first part of the paper presented a review of subsea production systems and current trends in associated technology. Examples of areas where technology is being developed with potential for extending the capabilities of subsea systems were presented. The development of this technology is one way in which subsea production can offer cost effective solutions to oil and gas production for reserves which can not justify a "conventional" platform type development. In this section of the paper, a specific aspect of subsea production is identified to look at ways in which the use of imaginative engineering design can offer significant cost savings to overall project costs. The discussion is restricted primarily to one aspect of a subsea production system for reasons of space and to offer some consistency to the discussion. However, the principles established in this section apply equally to all other aspects of a subsea production system.

During the years since 1985, nominal cost per barrel of developing fields in the UK sector of the North Sea has fallen by up to 40 percent. This is illustrated in Table 3.1 below and is largely attributable to the introduction of subsea production to develop 'marginal fields'.

Table 3.1

Field Development Nominal Cost Per Barrel

PROJECT	YEAR	CAPEX (US$/barrel)
Thames	1985	7.86
Humbley Grove		9.96
Tern		7.46
Scapa		3.45*
Eider		10.01
Ivanhoe	1986	6.69*
V-Fields		5.37
Petronella		4.32*
Cleeton		7.39
Audrey	1987	1.96
Ness		4.20*
Kittiwake		8.40
Arbroath		2.59
Glamis		4.50*

* Subsea/Floating Production Systems

Figure 3.1 illustrates overall cost breakdowns for selected subsea production systems. Typical single well and four well systems, tied-back to an existing host platform, have been selected for comparison. These pie-charts illustrate that pipeline costs, expressed as a proportion of total capital expenditure (excluding drilling), increase from 49 to 53 percent with a reduction in complexity from the four well to the single well system.

Examination of the material cost breakdown, illustrated in Figure 3.2, reveals that pipeline and riser material costs account for over 30 percent of total procurement costs. For the typical models used to generate these cost estimates, a reduction in the linepipe wall thickness requirement of just 1mm would lead to material cost savings in the order of 1.5 to 2 percent of total procurement costs, or approximately 1 percent of total project costs.

Consequently, rather than assuming the pipeline is a high fixed cost item, significant incentive exists for utilizing engineering effort in order to reduce this major cost item. Potential cost saving areas are identified in the following sections of this paper.

3.1 Overview of Pipeline Engineering

In summary, the major cost components in a pipeline system are as follows:

- linepipe;
- coatings;
    - corrosion;
    - insulation;
    - stability (concrete);
- installation;
- trenching/rock dump.

In order to define the primary parameters controlling requirements for these factors, traditional pipeline design requires a cycle of conceptual and detailed engineering leading to some degree of design optimization illustrated by the design spiral in Figure 3.3. This approach has essentially been developed for major trunklines where the pipeline may be considered a long term investment needed to satisfy the following objectives:

- to produce a pipeline which accommodates a full life design specification - typically 25 years;
- to produce a potential facility for future production;
- to allow the potential tie-in of future fields via tees or wyes.

However, although a composite 'Life Time' design specification may be appropriate for major trunklines, the primary objectives outlined above are unlikely to apply to small pipelines associated with subsea production systems. Typically, the design requirements for these will have the following characteristics:

- relatively short design life (5 to 15 years);
- short peak production plateau;
- rapid fall off in production levels;
- small potential for additional throughput via new field production.

Consequently, a fitness for purpose design approach is likely to lead to the most economical pipeline design for subsea production systems.

3.2 Fitness for Purpose Design Methodology

Perhaps the most striking aspect of designing small pipelines for subsea production systems is the almost infinite variance of the reservoir production characteristics. This is illustrated in Figures 3.4 to 3.6. Table 3.2 below summarizes this product characteristic variance for a typical reservoir over a 15 year period.

Table 3.2

Product Characteristic Variance

	YEAR 1	YEAR 5	YEAR 15
Production	High	High	Low
Gas/Oil Ratio	Low	Low	High
Wellhead Temperature	High	High	Low
Wellhead Pressure	High	Medium	Low
Corrosion Rate	Low	Low	High

Examination of this shows that whilst the production rate and associated wellhead pressure and temperature decrease with time, the gas/oil ratio and, most significantly, corrosion rate, increase. This variance leaves the pipeline design engineer with a major decision regarding final selection of design criteria. Traditionally, pipelines would be designed for the worst combination of these design factors, however, for subsea production system pipelines it may be more appropriate to utilize a fitness for purpose design approach. This type of design methodology can be interpreted in two key design strategies:

- lifetime design based upon varying system specification i.e. taking full account of production downturn during the later life of the system when the corrosion rate increases;
- limiting design life through to the end of plateau production followed by re-evaluation and/or further re-investment in the facilities.

In effect, the latter approach may be viewed as extended well testing and results in the potential for substantial deferred investment.

3.3 Coatings

The addition of coatings to pipelines is a major cost element in capital expenditure. Typically, coatings are specified for the following purposes:

- corrosion protection;
- insulation;
- stability.

However, in aiming to achieve cost reduction, it is critical that the pipeline design adequately considers the design premise resulting in specifications of a particular coating system.

For example, although corrosion coatings are normally specified, it may be more cost effective for short design life developments (up to 5 years) to accept external corrosion and accommodate this by a slight increase in wall thickness. Similarly, insulation is often added to satisfy an extremely rigorous specification developed to inhibit production problems (i.e. hydrate formation, waxing) for a range of critical flow conditions or to conform to a nominal platform process equipment specification. However, rather than attempting to solve these problems by addition of extremely expensive insulation coatings, it may be more cost effective to upgrade platform equipment or develop operating procedures that deal with such features as hydrate inhibition during shut-in conditions. In summary, the pipeline design engineer should examine the overall system facilities and specification prior to attempting to solve potential production problems by the simple addition of insulation coatings.

The use of concrete coating to provide sufficient on bottom weight to keep pipelines on location during extreme environmental conditions is standard practice resulting from two dimensional stability analysis. The major features of this approach are as follows:

- no horizontal sliding is accepted;
- on bottom weight increased to achieve acceptable factor of safety against sliding: typically 1.1;
- additional weight achieved by addition of coating or increase in wall thickness.

Although this approach is well proven and relatively economical for most applications, particular problems are experienced in areas of high current velocities, such as shallow water.

J P KENNY has developed an alternative approach to achieving the required design integrity called Induced Tension Stabilization (ITS). In principal, this method allows for some lateral pipeline movement, but controls this by the build up of longitudinal tension in the pipeline which is restrained at the end points. This approach requires the design engineer to have a good knowledge of the wave regime acting on the system in order to build up an accurate force model and thereby calculate the loadings on the end restraints and corresponding longitudinal pipeline tension.

A typical short crested wave force distribution is shown in Figure 3.9. This demonstrates the force regime in relation to the mobilized length. The results of calculation of the accumulated tension in a 2-inch pipeline during storm passage are shown in Figure 3.10, which identified a maximum value of 60 tonnes. This induced tension limited the lateral deflection of the pipeline as shown in Figure 3.11.

In order to achieve this induced tension, restraint of the pipeline ends and a limited amount of pretensioning is required. A number of practical systems have been developed with a typical unit illustrated in Figure 3.12.

By utilization of ITS in preference to traditional two-dimensional stability methods, J P KENNY has achieved significant reductions in capital cost estimates for a number of projects.

3.4 Trenching/Rock Dumping

Trenching or rock dump is typically specified for a number of reasons which may include protection, insulation or prevention of thermal buckling.

The use of rock dumping to prevent thermal buckling represents a significant expenditure item if specified for a subsea production system. Typically, thermal buckling may occur where the following conditions or combination of conditions are found:

- high temperature/pressure;
- small diameter and thin walled pipelines (i.e. low flexural stiffness);
- low submerged weight;
- low burial depth.

Engineered backfill or rock dumping is a proven method of reducing the potential for thermal buckling. Typical costs are high, as illustrated in Table 3.3 below.

Table 3.3

ROCK DUMP COST
(US$ million)

	DEPTH OF COVER		
LINE LENGTH	0.3 metre	0.5 metre	1.0 metre
2 km	0.7	0.9	1.9
5 km	1.1	1.8	4.0
10 km	1.8	3.0	7.5

However, the primary cause of thermal buckling is, of course, the high wellhead temperature typically associated with subsea production systems. On a recent project J P KENNY approached this problem directly by engineering a wellhead cooling loop designed to lower the pipeline operating temperature by the few degrees necessary to operate below the critical buckling temperature. This cooling loop, now in service, was integrated within the Wellhead Protection Structure as illustrated in Figure 3.13 and resulted in a minimal increase in capital expenditure in comparison to the cost associated with rock dumping to solve the same problem.

4.0 CONCLUSIONS

Subsea production systems tied to either fixed or floating facilities have come of age and proved their technical and commercial feasibility in an offshore environment and industry with ever increasing demands for technical excellence. Initial concerns regarding reliability of components in a subsea environment have been dispelled by significant experience and track record. Efforts now concentrate on refining and improving the technology utilized in subsea systems to offer significant economies and cost savings to the overall systems. The technology areas receiving attention cover the entire range of activities associated with subsea production, from design of individual process components through to construction and commissioning applications.

With the ever improving capabilities of subsea production in relevant applications, the advantages to be gained become more poignant. From a project viewpoint, several more pertinent advantages are as follows:

- Shorter project schedule from decision to first production with associated cashflow advantages;
- Lower up front capital expenditure when compared to fixed platform option;
- The ability to adopt a phased approach to developing the resources;
- The ability to plan facilities and reservoir development based on information gained from earlier phases of development.

With the increasing complexity of subsea systems, particularly as many new technology areas are developed, there is an increasing need to engineer the overall system from an early stage of development in order to ensure a consistent and cohesive design is developed. For any aspect of design, as well as the overall system, the following design approaches should be considered to minimize overall costs:

- Screening of sufficient alternative solutions to achieve minimum cost;
- Fitness for purpose design;
- Use of a realistic Design Premise;
- Development of practical solutions to analytical problems by engineering.

In conclusion; the development of natural resources offshore Newfoundland is beginning with the Hibernia project. The location and environment offshore Newfoundland offer some unique technical and commercial challenges to industry participants. Just as, initially the Gulf of Mexico and subsequently the North Sea, formed the learning grounds and knowledge bases for the offshore industry, offshore Newfoundland has the potential to take the lead in particular areas of offshore and specifically subsea technology relating to the unique problems faced by the area.

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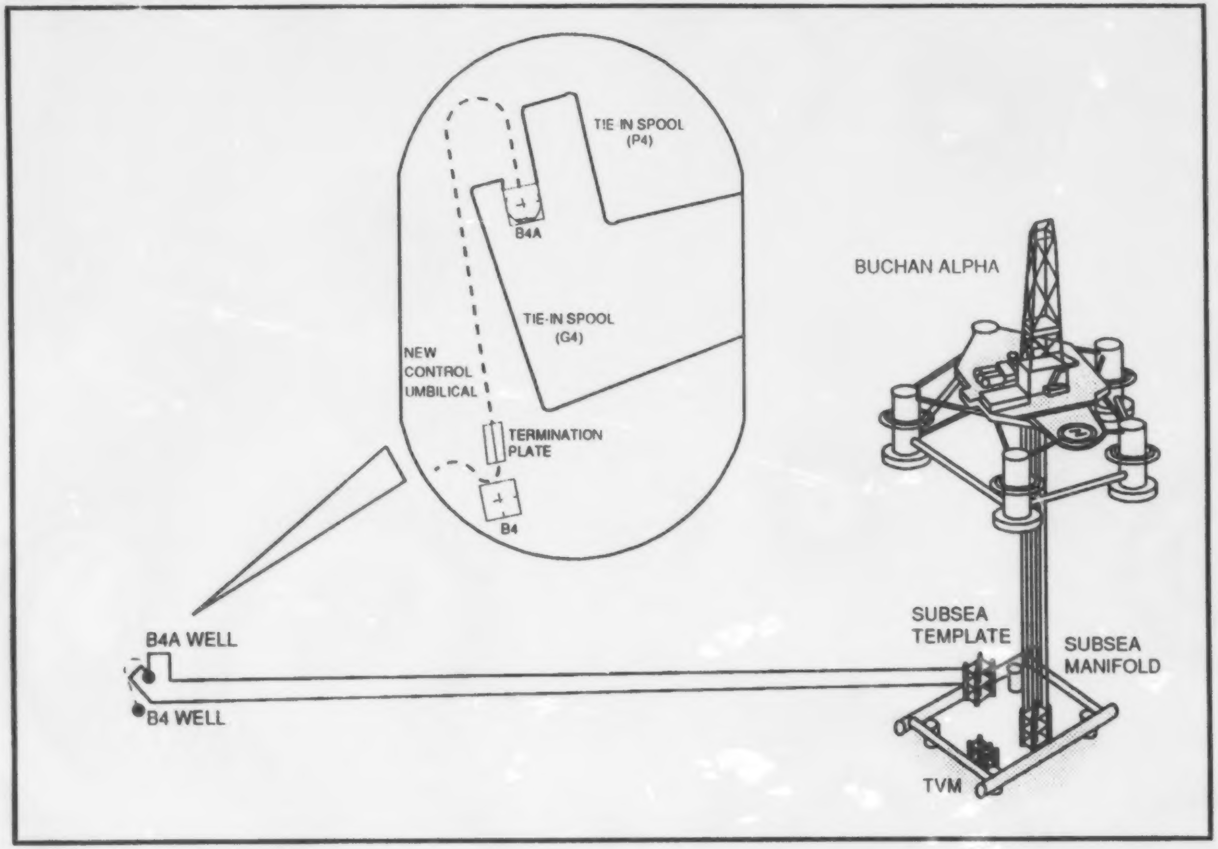
3. Effective Design Methods for Constructing Economical Pipelines for Marginal Fields, Pipelines for Marginal Fields Conference, September 1988, D A Phillips and S Whitaker.

SINGLE SATELLITE WELL TIED TO HOST FACILITY


TIE IN SPOOL (P4)
B4A
TIE-IN SPOOL (G4)
NEW CONTROL UMBILICAL
TERMINATION PLATE
B4
BUCHAN ALPHA
B4A WELL
B4 WELL
SUBSEA TEMPLATE
SUBSEA MANIFOLD
TVM

J P KENNY

FIGURE 2.1

MULTI-WELL SYSTEM TIED TO HOST FACILITY

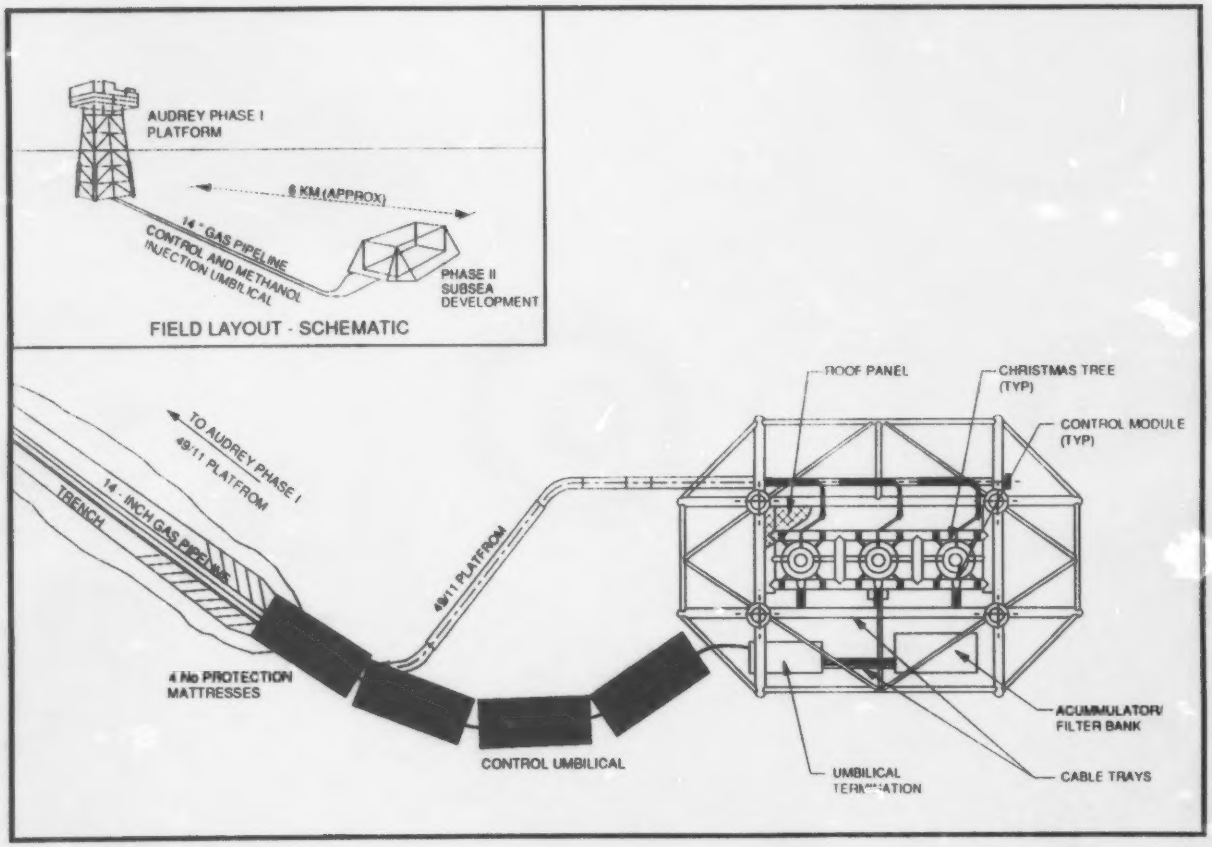

AUDREY PHASE I PLATFORM
6 KM (APPROX)
14" GAS PIPELINE
CONTROL AND METHANOL INJECTION UMBILICAL
PHASE II SUBSEA DEVELOPMENT
FIELD LAYOUT - SCHEMATIC
TO AUDREY PHASE I 49/11 PLATFROM
14 - INCH GAS PIPELINE
TRENCH
49/11 PLATFROM
4 No PROTECTION MATTRESSES
CONTROL UMBILICAL
ROOF PANEL
CHRISTMAS TREE (TYP)
CONTROL MODULE (TYP)
ACUMMULATOR/ FILTER BANK
UMBILICAL TERMINATION
CABLE TRAYS

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FIGURE 2.2

SEPARATE FIELD SYSTEM TIED TO HOST FACILITY

SUBSEA DEVELOPMENT CONCEPT

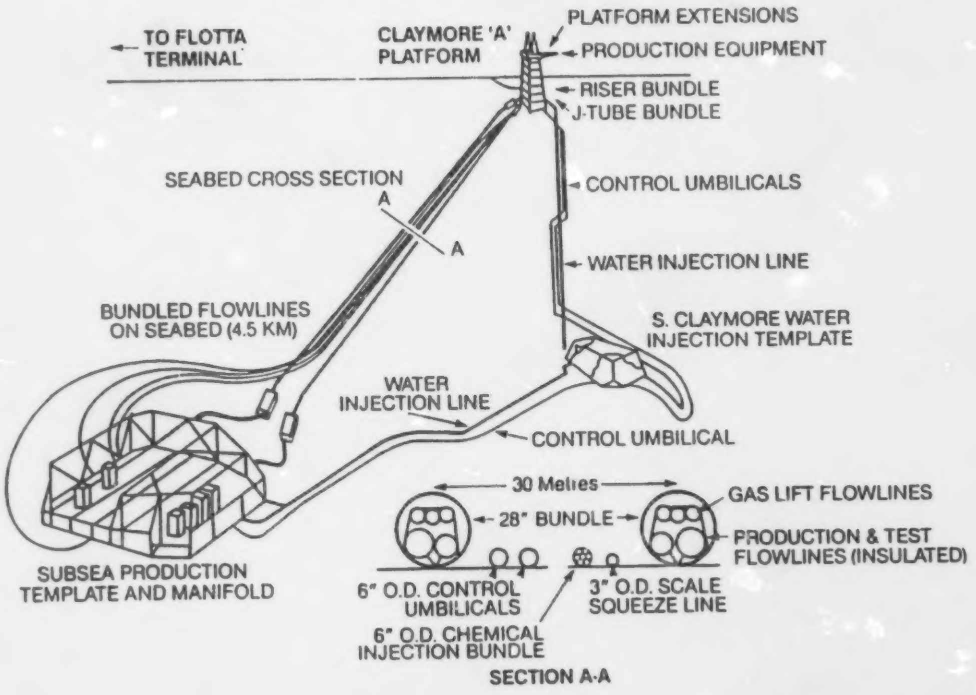
TO FLOTTA TERMINAL
CLAYMORE 'A' PLATFORM
PLATFORM EXTENSIONS
PRODUCTION EQUIPMENT
RISER BUNDLE
J-TUBE BUNDLE
CONTROL UMBILICALS
SEABED CROSS SECTION
A
A
WATER INJECTION LINE
BUNDLED FLOWLINES ON SEABED (4.5 KM)
S. CLAYMORE WATER INJECTION TEMPLATE
WATER INJECTION LINE
CONTROL UMBILICAL
30 Metres
28" BUNDLE
GAS LIFT FLOWLINES
PRODUCTION & TEST FLOWLINES (INSULATED)
SUBSEA PRODUCTION TEMPLATE AND MANIFOLD
6" O.D. CONTROL UMBILICALS
3" O.D. SCALE SQUEEZE LINE
6" O.D. CHEMICAL INJECTION BUNDLE
SECTION A-A

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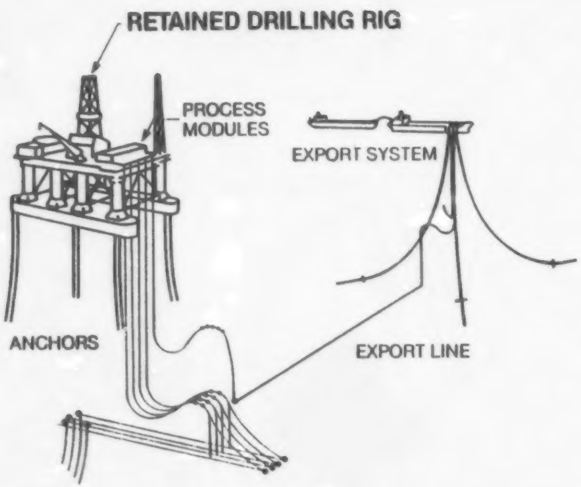
FIGURE 2.3

SEPARATE FIELD SYSTEM TIED TO FPV


RETAINED DRILLING RIG
PROCESS MODULES
EXPORT SYSTEM
ANCHORS
EXPORT LINE

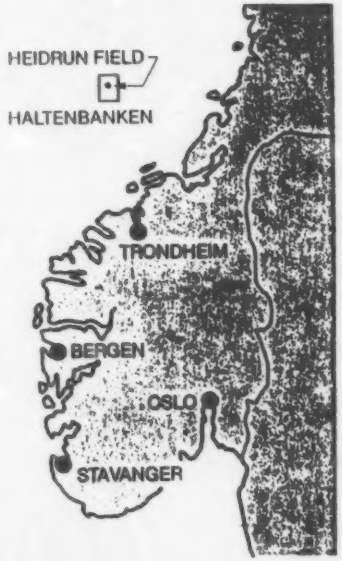
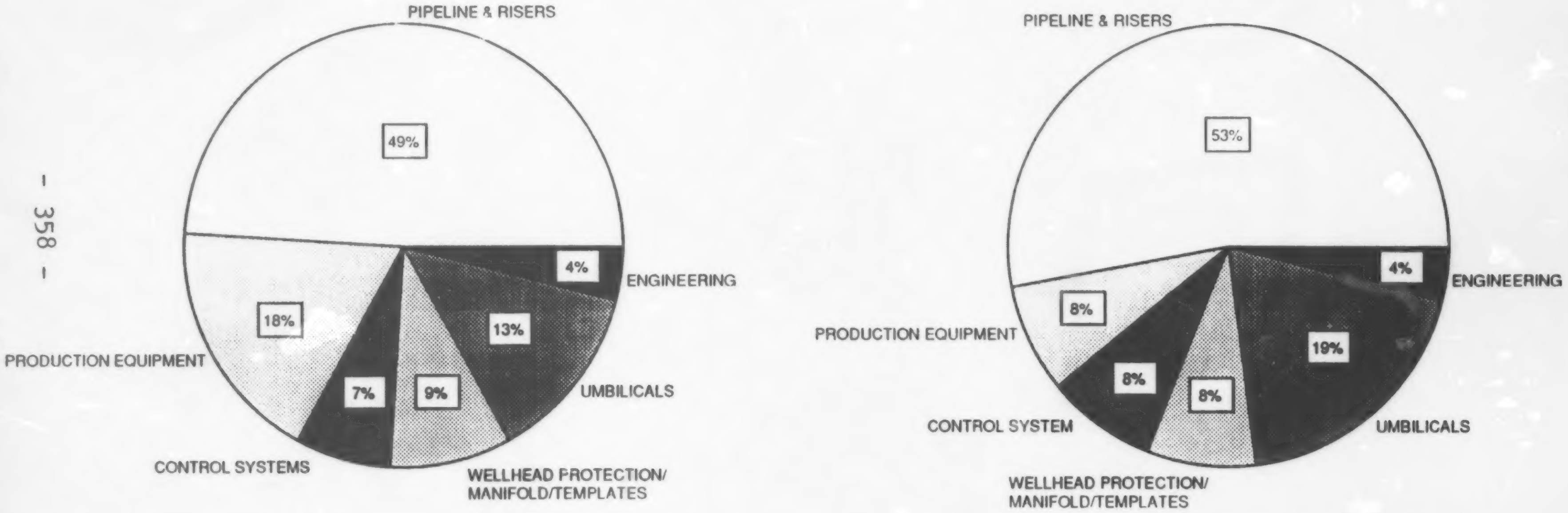

HEIDRUN FIELD
HALTENBANKEN
TRONDHEIM
BERGEN
OSLO
STAVANGER

FIGURE 2.4

SUBSEA PRODUCTION SYSTEMS

TYPICAL COST BREAKDOWN - TOTAL COSTS



TYPICAL 4-WELL SYSTEM

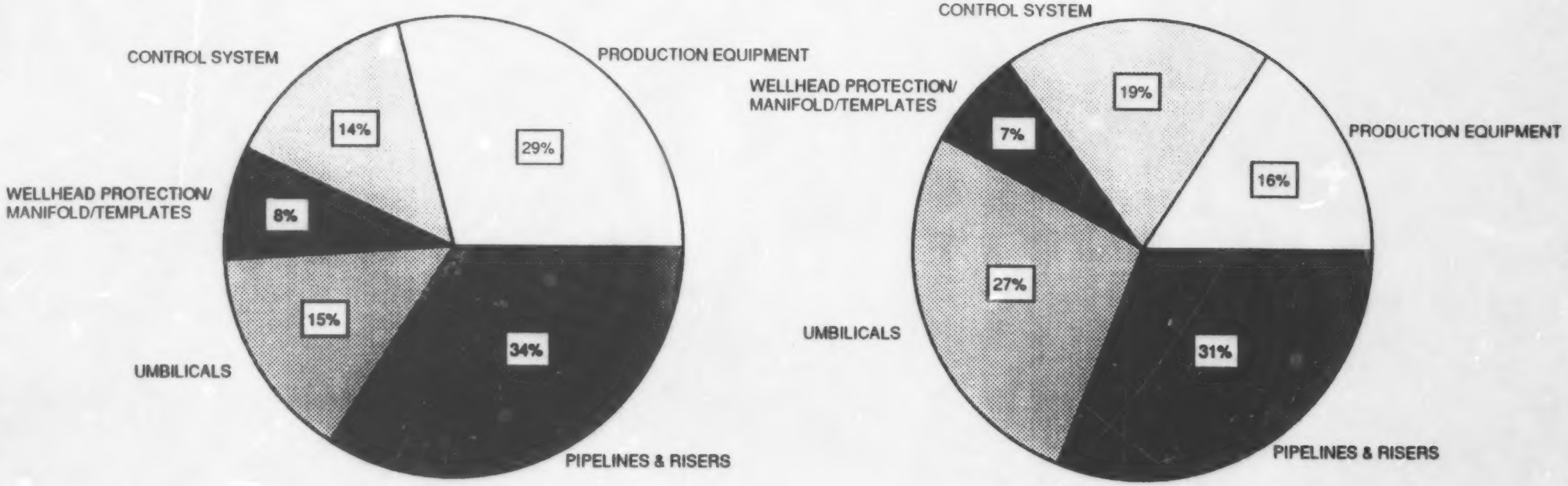
TYPICAL SINGLE WELL SYSTEM

J P KENNY

FIGURE 3.1

SUBSEA PRODUCTION SYSTEMS

TYPICAL COST BREAKDOWN - MATERIAL COSTS

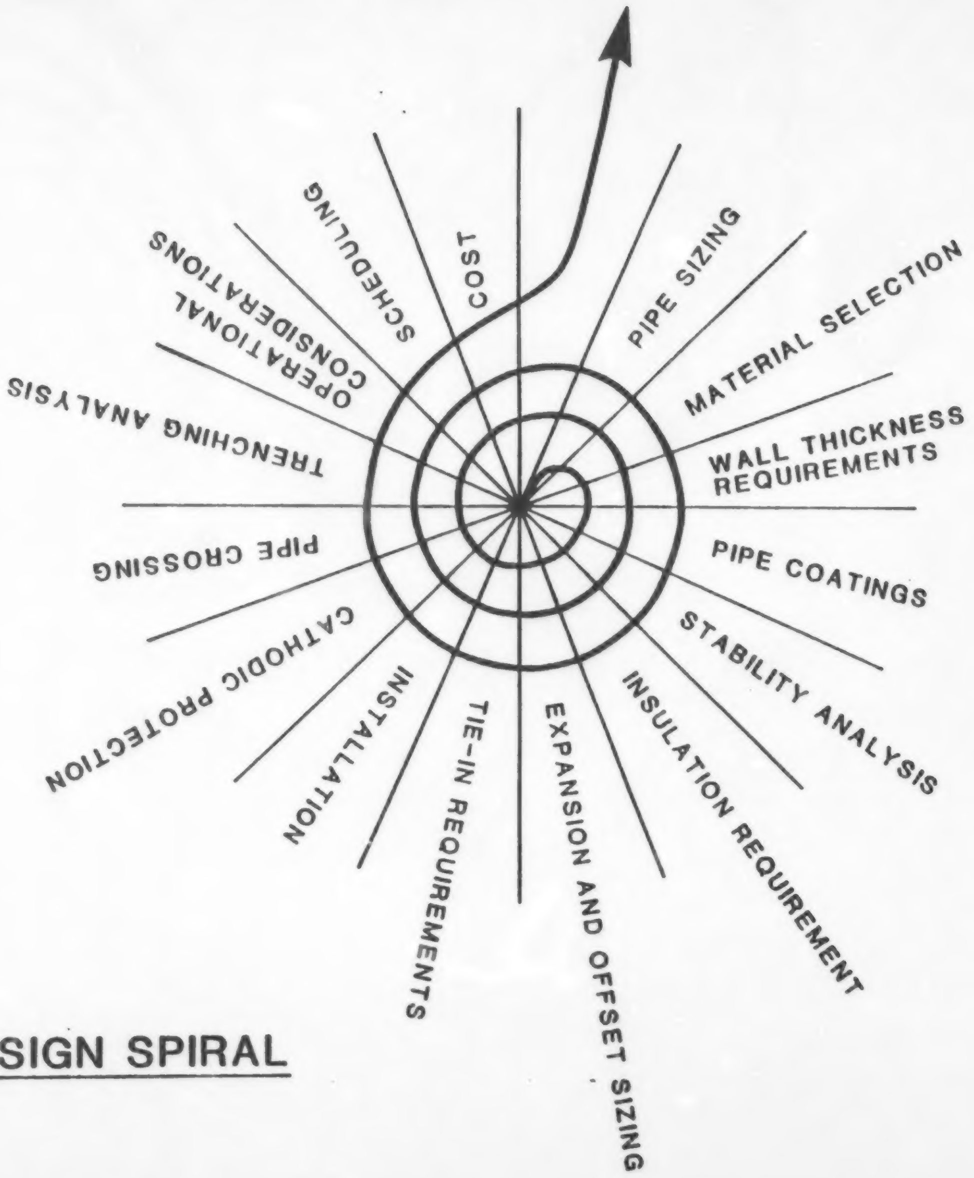


TYPICAL 4-WELL SYSTEM

TYPICAL SINGLE WELL SYSTEM

J P KENNY

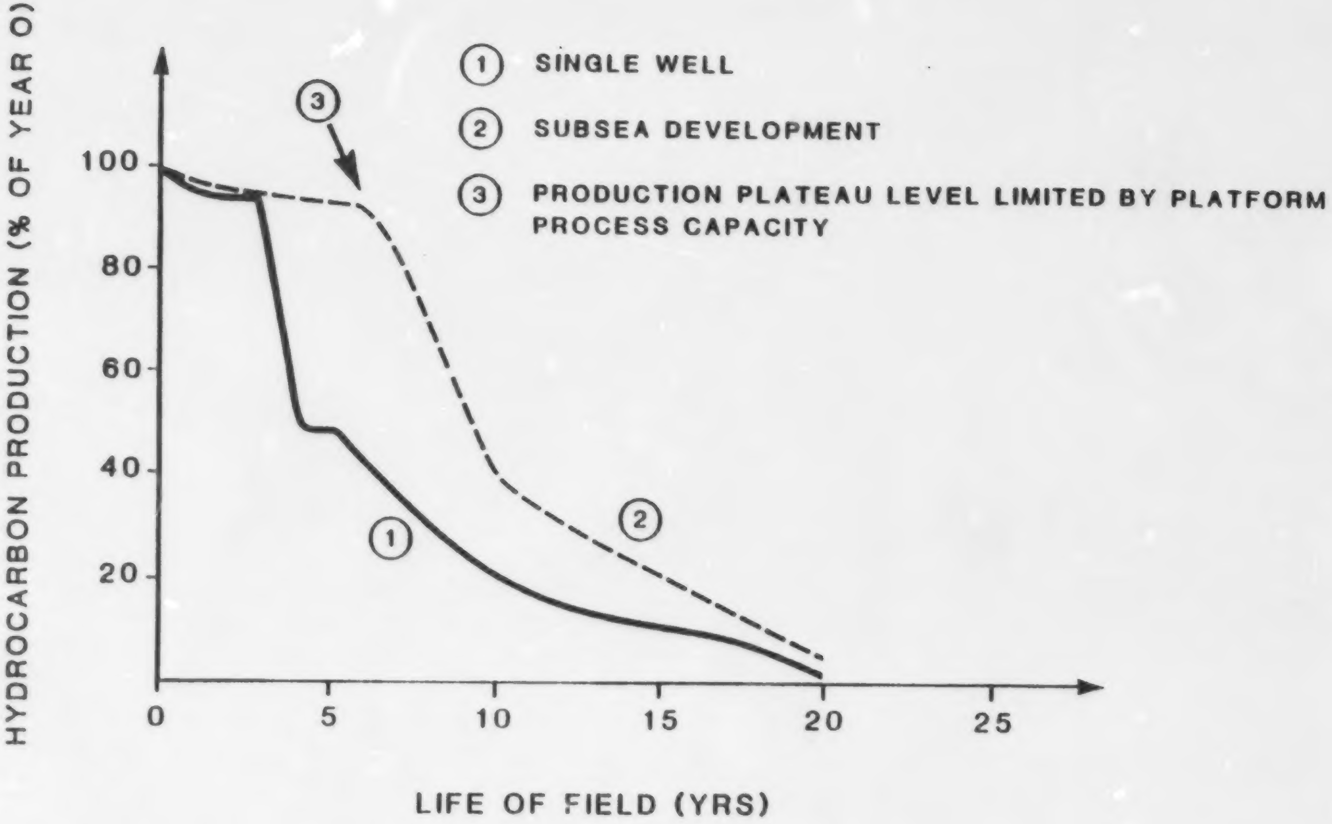
FIGURE 3.2


PIPE SIZING
MATERIAL SELECTION
WALL THICKNESS REQUIREMENTS
PIPE COATINGS
STABILITY ANALYSIS
INSULATION REQUIREMENT
EXPANSION AND OFFSET SIZING
TIE-IN REQUIREMENTS
INSTALLATION
CATHODIC PROTECTION
PIPE CROSSING
TRENCHING ANALYSIS
OPERATIONAL CONSIDERATIONS
SCHEDULING
COST

DESIGN SPIRAL

J P KENNY

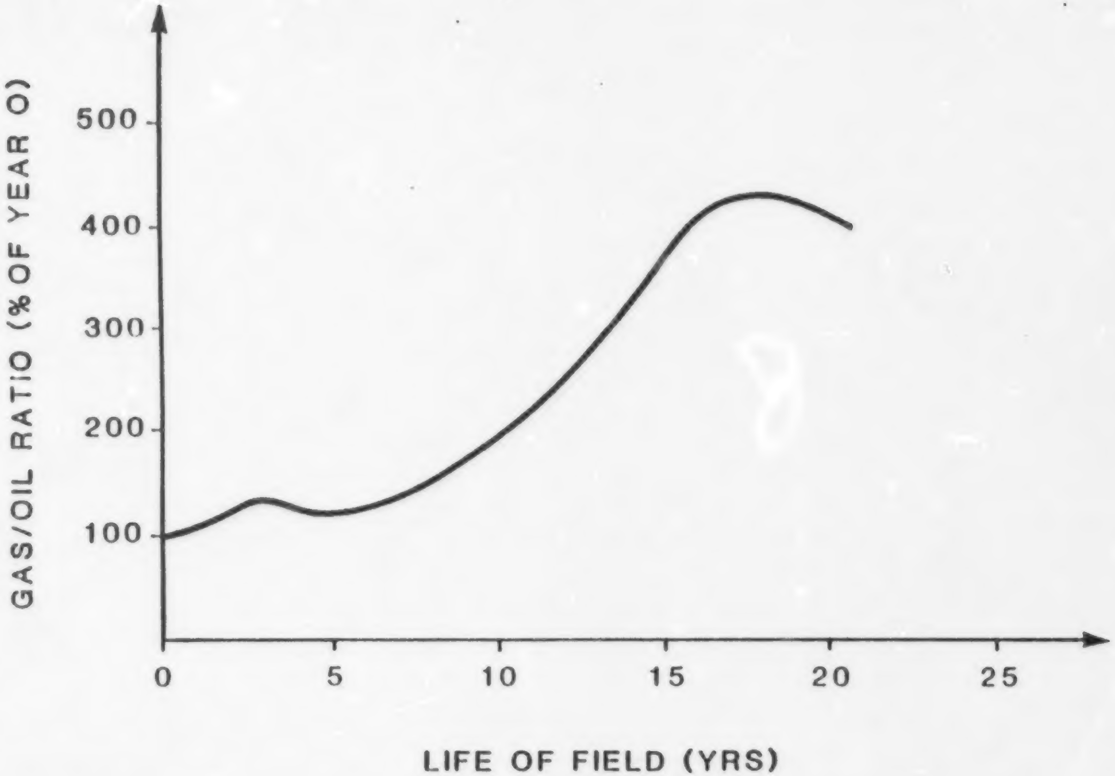
FIGURE 3.3



GRAPH OF
HYDROCARBON PRODUCTION
AGAINST FIELD LIFE

J P KENNY

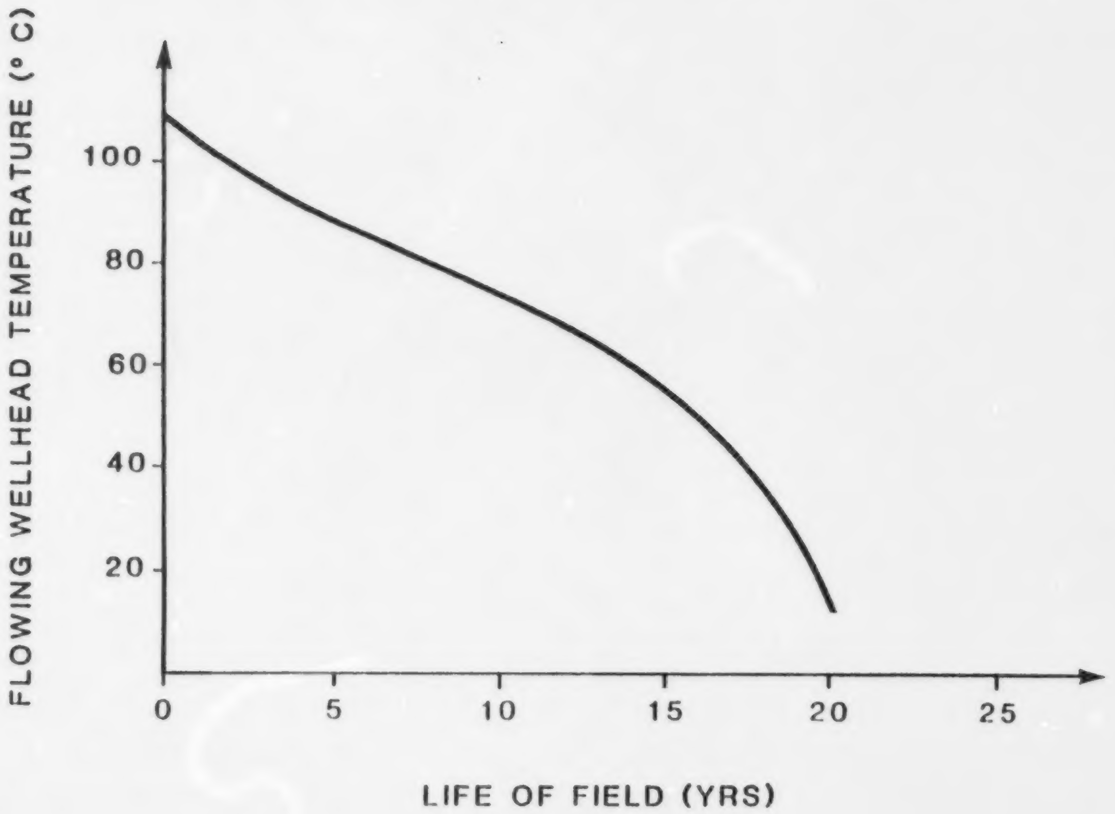
FIGURE 3.4



GRAPH OF

GAS/OIL RATIO AGAINST FIELD LIFE

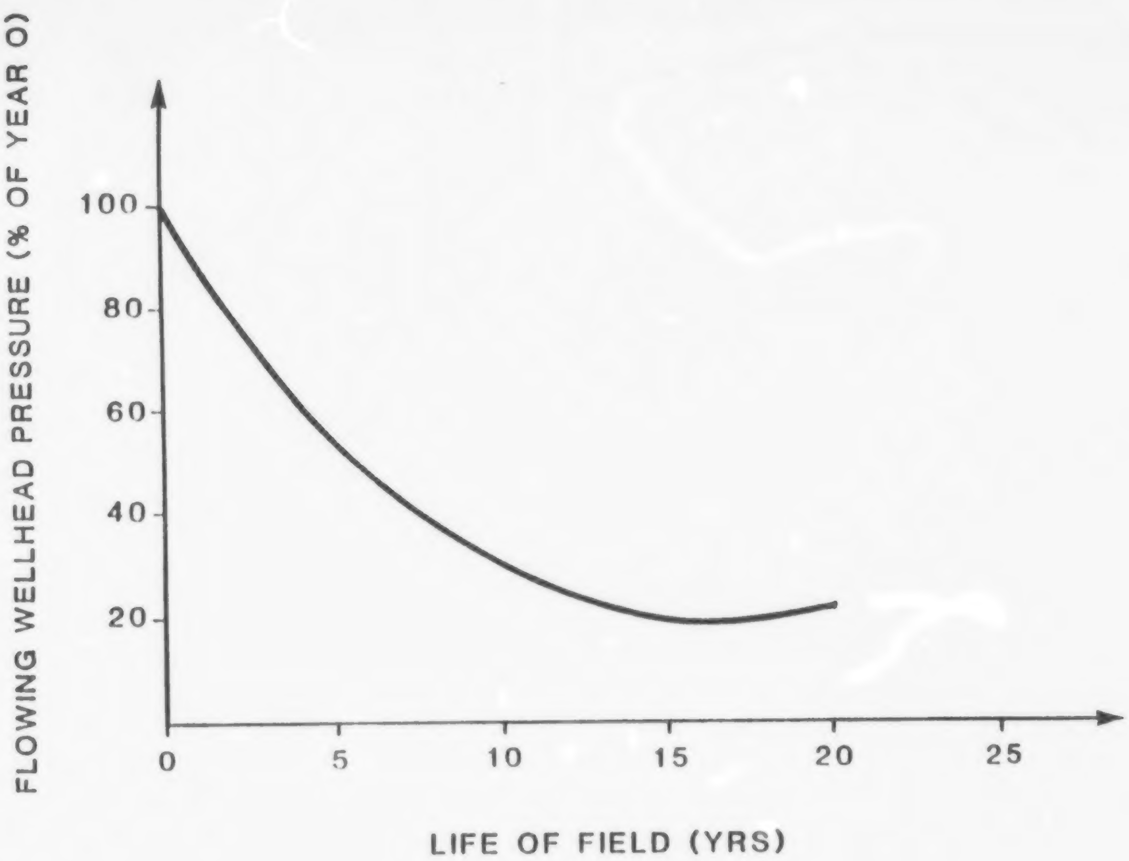
FIGURE 3.5



GRAPH OF
FLOWING WELLHEAD TEMPERATURE (FWHT)
AGAINST FIELD LIFE

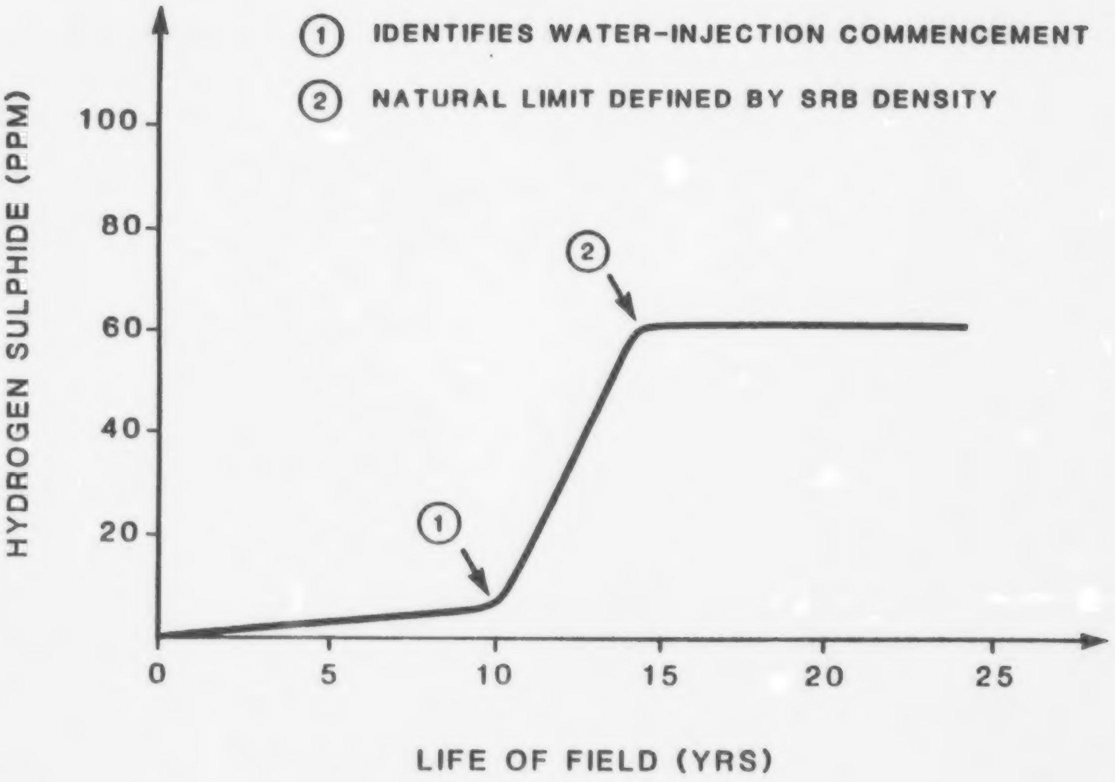
J P KENNY

FIGURE 3.6



GRAPH OF
FLOWING WELLHEAD PRESSURE (FWHP)
AGAINST FIELD LIFE

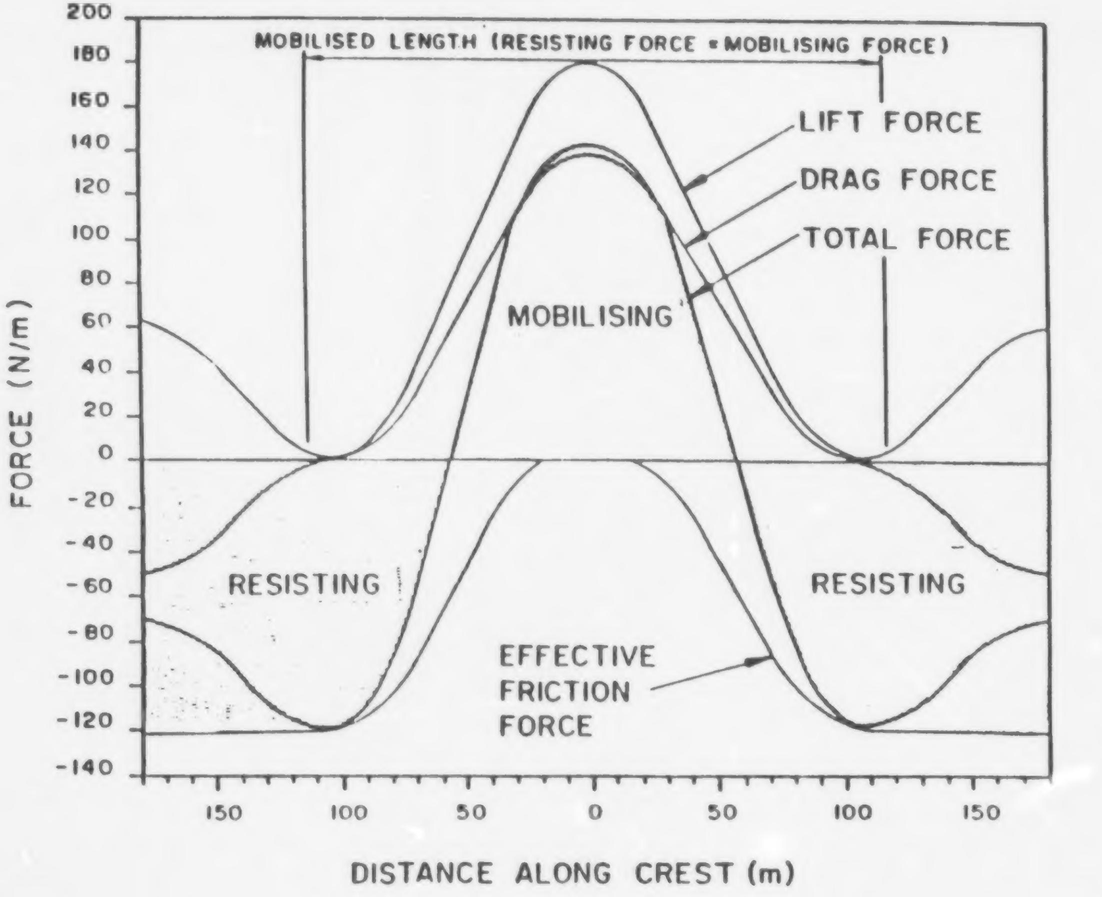
FIGURE 3.7



GRAPH OF
HYDROGEN SULPHIDE
AGAINST FIELD LIFE

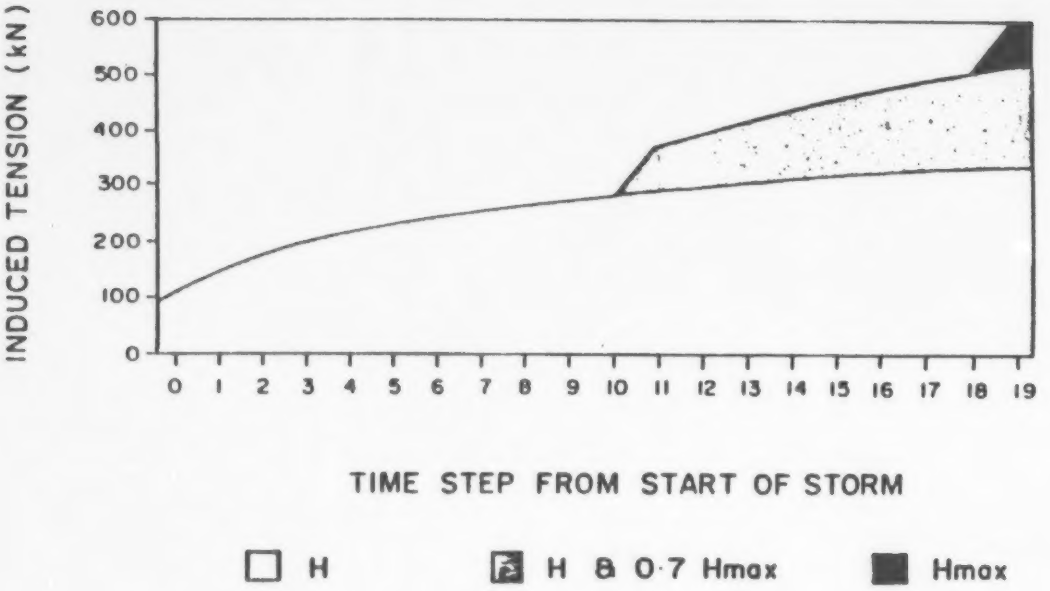
J P KENNY

FIGURE 3.8



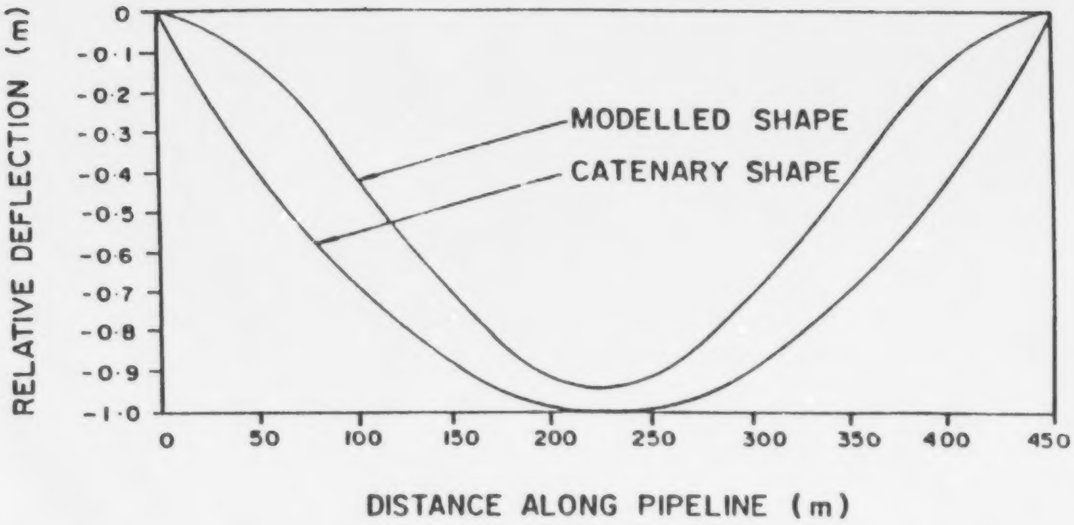
TYPICAL SHORT CRESTED WAVE FORCE DISTRIBUTION

FIGURE 3.9



ACCUMULATION OF TENSION IN 2" DIA. LINE
WITH STORM PASSAGE

FIGURE 3.10



ASSUMED DEFECTED SHAPE

FIGURE 3.11

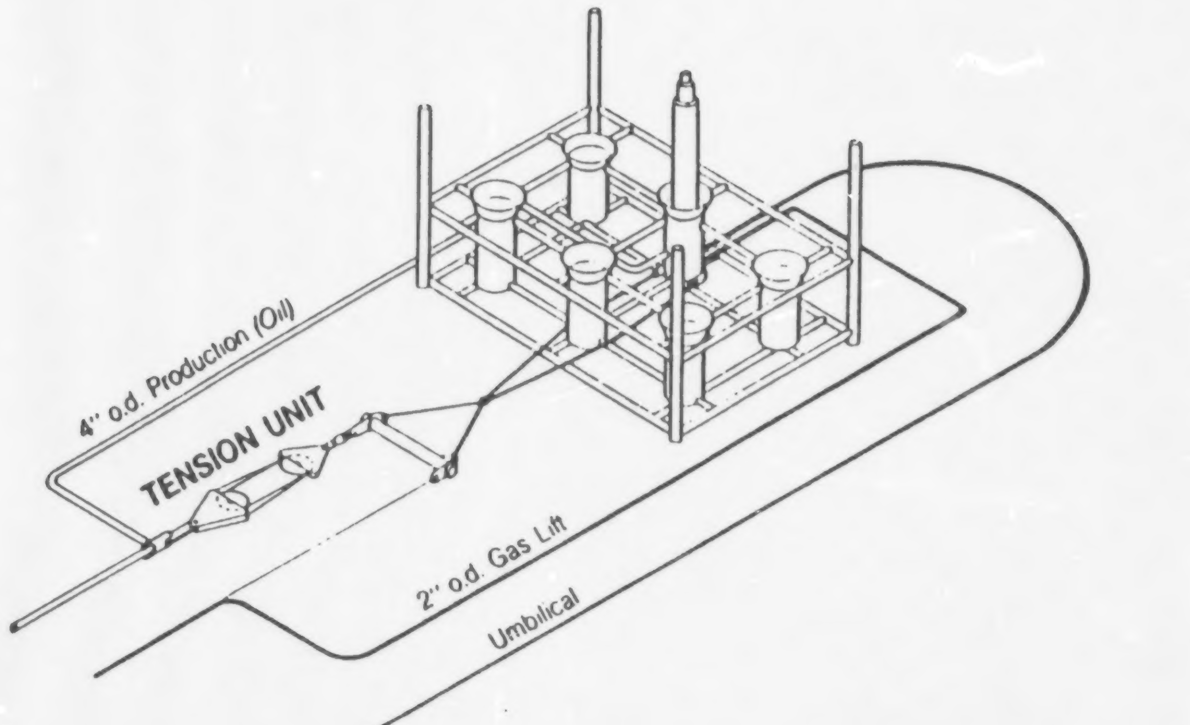
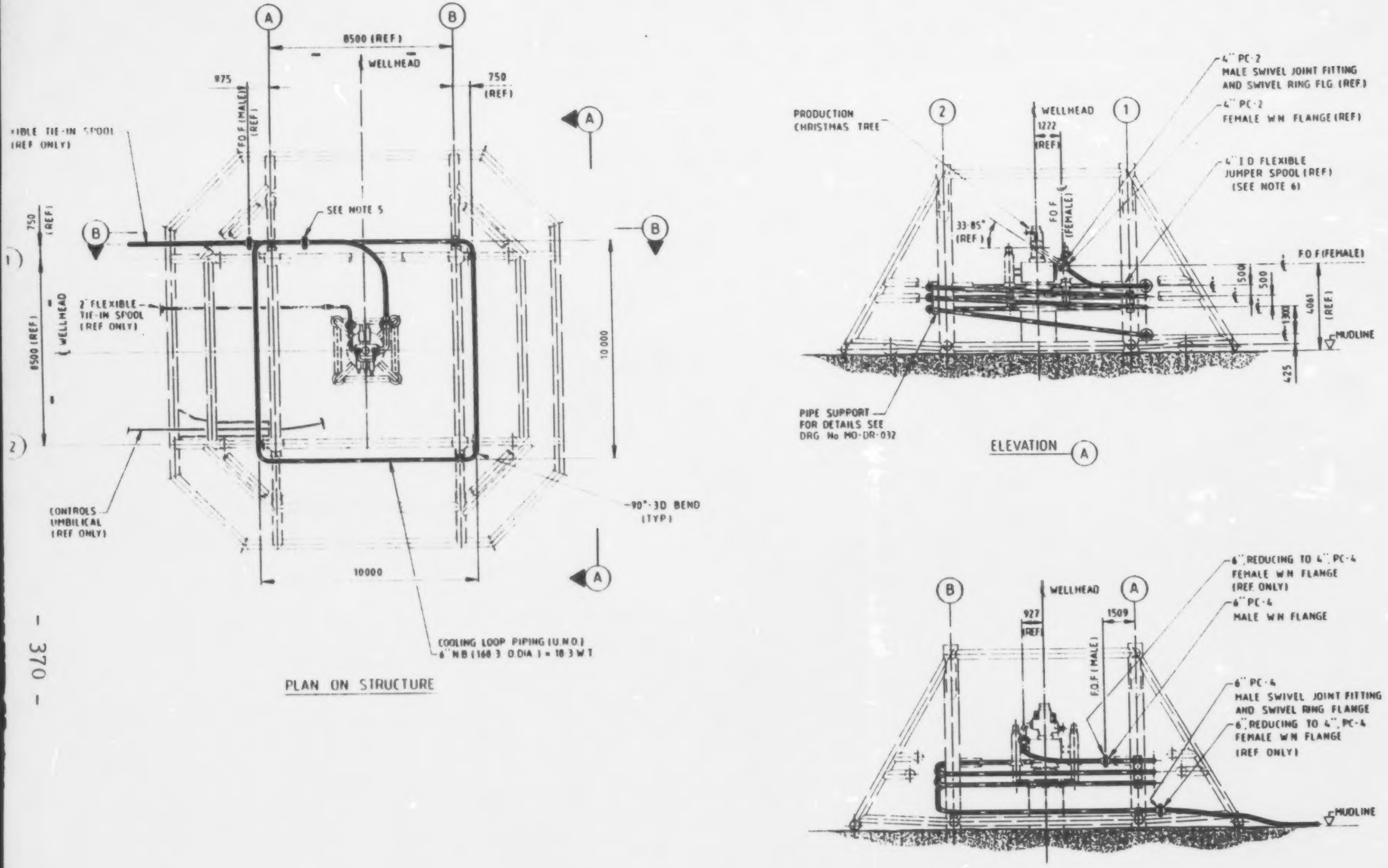

4'' o.d. Production (Oil)
TENSION UNIT
2'' o.d. Gas Lift
Umbilical

FIGURE 3.12



A
B
8500 (REF)
WELLHEAD
975
F.O.F (MALE) (REF)
750 (REF)
IBLE TIE-IN SPOOL (REF ONLY)
SEE NOTE 5
750 (REF)
8500 (REF)
WELLHEAD
2" FLEXIBLE TIE-IN SPOOL (REF ONLY)
10 000
CONTROLS UMBILICAL (REF ONLY)
90°-3D BEND (TYP)
10000
COOLING LOOP PIPING (U.N.O.)
6" NB (168.3 O.DIA.) = 18.3 W.T.
PLAN ON STRUCTURE
PRODUCTION CHRISTMAS TREE
2
WELLHEAD
1222 (REF)
1
4" PC-2 MALE SWIVEL JOINT FITTING AND SWIVEL RING FLG (REF)
4" PC-2 FEMALE WN FLANGE (REF)
4" I.D FLEXIBLE JUMPER SPOOL (REF) (SEE NOTE 6)
33.85° (REF)
F.O.F (FEMALE)
F.O.F (FEMALE)
500
500
1300
4061 (REF)
MUDLINE
425
PIPE SUPPORT FOR DETAILS SEE DRG No MO-DR-032
ELEVATION A
B
WELLHEAD
A
927 (REF)
1509
F.O.F (MALE)
6" REDUCING TO 4" PC-4 FEMALE WN FLANGE (REF ONLY)
6" PC-4 MALE WN FLANGE
6" PC-4 MALE SWIVEL JOINT FITTING AND SWIVEL RING FLANGE
6" REDUCING TO 4" PC-4 FEMALE WN FLANGE (REF ONLY)
MUDLINE

J P KENNY

FIGURE 3.13

91/65

NOTES FOR AN ADDRESS
BY
THE HONOURABLE JAKE EPP
MINISTER OF ENERGY, MINES AND RESOURCES CANADA
AND MEMBER OF PARLIAMENT FOR PROVENCHER

TO

THE NEWFOUNDLAND OCEAN INDUSTRIES ASSOCIATION

ST. JOHN'S, NEWFOUNDLAND
JUNE 19, 1991

Good afternoon ladies and gentlemen. I'm delighted to be here this afternoon to offer some remarks on the conclusion of this year's Newfoundland Ocean Industries Association Conference.

I am sure you would all agree that this year's conference has special significance. That significance is summed up in the conference theme: Offshore Newfoundland; The Birth of an Industry. The birth was a long time coming, waiting on Hibernia for its parentage. But the wait has been well worth it.

Today there are over 1300 people working on the project. More than half are working here in Newfoundland and most of the rest are working in other locations in Canada. Commitments of more than two billion dollars in expenditures have been made by the project owners, with another three billion dollars to follow over the next five years. Consequently, Newfoundland is expected to lead the country in economic growth this year, a distinction which it richly deserves.

Competitiveness and the Offshore

But Hibernia and the industry which it has fostered is about more than just numbers, impressive as they are. It's about investing in our future and creating economic opportunities, not only for today, but for tomorrow. For the people of Newfoundland and Labrador it is the opportunity to use their skills and ingenuity to broaden their economic horizons and to create a new source of jobs for themselves and for their children. For the rest of us throughout the country it is the chance to demonstrate our ability to compete for business in one of the world's most demanding and technically complex market places.

It's not just jobs we are talking about here. It's really about the type of jobs Canadians will need for the kind of competitive world we are heading into. No longer can we rely solely on the extraction or harvesting of our resources for our economic well being. If we are to meet the challenges of global competition, we must use our resources as a spring board to diversify and enhance the competitiveness of the Canadian economy.

We cannot afford to be complacent in the face of an ever more competitive and technologically sophisticated world. The risks to our way of life are too great. They were recognized in the recent speech from the throne which reminded us that "the risk for Canada is not so much to be undercut by developing countries with low wage economies, but to be out-performed by technologically advanced countries with highly paid, highly skilled workers".

And so for me the birth of a new industry here is an example to all Canadians of the kind of vision and investment in our future that are vital to ensuring our economic well being and our quality of life. And that is why I believe there's much to be learned from Hibernia. What you have done to prepare for it can guide us in meeting the competitive challenge which lies ahead.

Role of Industry and Government

Long before the announcement of Hibernia, companies in Newfoundland were actively seeking partners with offshore experience to help them prepare to bid on the first offshore contracts. Those efforts have paid off handsomely. I am told that of the 12 largest contracts awarded to date, Newfoundland firms are direct participants in three-quarters of them.

While you have been building cooperative arrangements with foreign companies, you've also been busy here at home ensuring that the skills and infrastructure necessary for a new offshore industry were put in place. I am proud to say that the federal government, through the Canada-Newfoundland Offshore Development Fund, has played an important role in supporting your efforts.

The development fund is a $300 million investment in Newfoundland's future as a major supplier to the offshore. The $300 million available from the fund is shared 75 per cent by the federal government and 25 per cent by the provincial government. The fund has already supported an impressive range of initiatives. At Memorial University, for example, financing has been provided for a Centre for Earth Resources Research and a Centre for Offshore and Remote Medicine and Telemedicine. We have also provided support for the Institute of Marine Dynamics, a new offshore survival centre, and the world's most advanced marine simulator for the offshore.

These facilities, taken together with contributions from the development fund for the Bull Arm construction site and the metal fabrication site at Cow Head, mean that Newfoundland now has facilities second to none to service and supply the offshore oil and gas industry, not only at home but throughout the world.

The fund also plays a key role in training Newfoundlanders to acquire new skills that will be needed for offshore development. For example, the Offshore Technology Transfer Opportunities Program gives local firms the chance to participate in on-site training programs with major international suppliers to the oil and gas industry. Other programs provide training in offshore disciplines at institutes and colleges throughout the province. To date, more than 1 500 people have been trained as a result of development fund projects.

Technological Opportunities

Another important aspect of the fund's activities is support for research and development. That's essential because the development of offshore oil and gas resources depends critically on advanced technology and innovation. But what's even more important is that innovation is the key to international competitiveness. Innovation creates new industries, new technologies, and, above all, new jobs: new jobs that are highly skilled and highly paid.

I was therefore delighted to learn that you spent a full day yesterday considering innovative technology for Hibernia. I don't need to tell you that with the redesign of the Hibernia topsides, the project is now at the leading edge of platform design and fabrication. I take pride in knowing that we will design most of it in Canada and build a great deal of it in Newfoundland.

In the long term, the technology and skills that are acquired in designing and building Hibernia will be far more important than the project itself. What you learn can be applied to let you play an even larger role in future projects in Canada's offshore. But what's more important is that these new skills can be taken into international markets and can be applied in other industrial sectors. By doing things smarter we can do things better, not only in supplying the oil and gas industry but throughout the economy.

Cooperation

But no industry is born fully grown and entirely self-sufficient. If I have spoken at some length about my pride in the role that the people of this province and the rest of Canada are playing in making Hibernia a reality, I also want to acknowledge the important contribution that our friends from abroad are making.

Many of the foreign companies that are here today have been coming to this conference since its inception and have been steadfast in their belief in the development of the Canadian offshore. A good many of you have actively sought joint venture partners or have entered into other arrangements which will bring direct benefits to the Newfoundland and Canadian economies as well as to your own companies.

I congratulate you on the farsighted approach you have taken to doing business here. After all, cooperation and working together is yet another lesson which we can learn from the development of Hibernia. Making Hibernia a reality has required four oil companies to come together to develop and operate the project. It required the federal and provincial governments to put any differences aside and to agree to cooperate in managing the offshore through the Atlantic Accord. It has required both governments and the four Hibernia partners to reach a complex agreement to finance the project. And now it requires an equal measure of cooperation and agreement among designers, contractors and fabricators to build it.

Hibernia is a great enterprise. It has demanded faith in the future and a willingness to cooperate. As we contemplate the even larger enterprise of national renewal, we will do well to remember these lessons of Hibernia.

Beyond Hibernia

Hibernia was a long time coming. I am confident that we will not have nearly as long to wait for the next development in the Newfoundland offshore.

We know the oil is there to spark new developments. Both Terra Nova and Whiterose appear large enough to support development in their own right. Other smaller fields like Hebron are also candidates for development, either through tie-ins to existing fields or by the kind of imaginative approach to small field development which has been demonstrated by industry at Cohasset-Panuke off Nova Scotia.

We also know there are good prospects that more oil and gas will be found. As many of you will know, the Geological Survey of Canada and the Canada Newfoundland Offshore Petroleum Board have just issued a report confirming that the Jeanne D'arc Basin, where Hibernia is located, continues to be an attractive place to explore.

Beginnings are always difficult. What gives me confidence in new discoveries and early development of existing prospects, is that the beginnings have now been made. By making the development of Hibernia a reality we have laid the foundation not only for a new supply industry but for the further exploration and development of the rich oil and gas resources in the Newfoundland offshore.

As the oil and gas industry considers where next to put its exploration and development dollars, it can be confident that the infrastructure and trained workers are available here in Newfoundland to support its efforts. That should considerably reduce the uncertainty and risk which are inevitably a part of all offshore activities.

Conclusion

It seems to me as we come to the close of this year's conference that the ingredients are all in place for the healthy growth and development of the new offshore industry to which Hibernia has given birth.

New exploration rights have been awarded on the west coast of Newfoundland and two exploratory wells will be drilled on the Grand Banks over the summer.

Joint ventures are in place, research is underway, infrastructure has been developed and workers have been trained. And more investment and training is planned.

Contracts are now being awarded on almost a daily basis and the construction site at Bull Arm should be ready to begin building the Hibernia platform early next year.

Prospects for future development have been identified.

I think it may confidently be said that the long wait is over. A new industry which will help carry Newfoundland well into the 21st century has been born.

Thank you for inviting me to its christening.

LIST OF CONFERENCE SPEAKERS

Mr. Derek Owen
Project General Manager
HIBERNIA PROJECT TEAM
Suite 301, Scotia Centre
235 Water Street
St. John's, NF
A1C 1B5

Tel: (709) 570-7000
Fax: (709) 753-2209

Fraser Edison
President
NODECO
66 Kenmount Road
Suite 202
P.O. Box 2446
St. John's, NF
A1C 6E7

Tel: (709) 753-4651
Fax: (709) 753-5503

L.F. Rolstad
Project Manager
NEWFOUNDLAND
OFFSHORE
CONTRACTORS - NOC
7777 Decarie Blvd.
Montreal, Quebec
H4P 2S6

Tel: (514) 345-6500
Fax: (514) 345-9961

David J. Croston
CA Project Manager
LLOYD'S REGISTER
1450 City Councillors #700
Montreal, Quebec
H3A 2E6

Tel: (514) 345-6568
Fax: (514) 849-0741

Pip Rudkin
ATLANTIC AIRWAYS
P.O. Box 9460
St. John's, NF
A1A 2Y4

Tel: (709) 576-1800
Fax: (709) 576-1802

Joe Ryan
President
SIGMA ENGINEERING
LIMITED
P.O. Box 5414
St. John's, NF A1C 5W2

Tel: (709) 726-5086
Fax: (709) 753-0707

Dr. A.M. Ponsford
Senior Communications
Specialist
NORDCO LIMITED
P.O. Box 8833
St. John's, NF A1B 3T2

Tel: (709) 747-0566
Fax: (709) 747-3550

Derek Langford
Engineering Manager
NEWFOUNDLAND
OFFSHORE
CONTRACTORS - NOC
7777 Decarie Blvd.
Montreal, Quebec
H4P 2S6

Tel: (514) 345-6500
Fax: (514) 345-9961

Nicolas Parsloe
NODECO
P.O. Box 2446
St. John's, NF
A1C 6E7

Tel: (709) 753-4651
Fax: (709) 753-5503

Steven M. Millan
Associate Director
CENTRE FOR COLD
OCEAN RESOURCES
ENGINEERING - C-CORE
Captain Robert A. Bartlett
Building
Memorial University
St. John's, NF A1B 3X5

Tel: (709) 737-8354
Fax: (709) 737-4706

Iain Sinclair
Senior Geologist
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
5th Floor, TD Place
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1400
Fax: (709) 778-1473

Gary C. Bruce
Vice-President, New
Development
PETRO-CANADA
RESOURCES
P.O. Box 2844
Calgary, Alberta
T2P 3E3

Tel: (403) 296-3521
Fax: (403) 296-3030

Torbjorn Mehli
Project Director for
Marketing & Technology
Division
AKER A.S.
Fjordalleen 16
Aker Brygge
Postboks 1423 Vika
0115 Oslo 1, Norway

Tel: (02) 94 50 00
Fax: (02) 94 50 16

Murray H. Chancellor
Vice-President
JP KENNY OFFSHORE
ENGINEERING (CANADA)
LIMITED
Suite 802, Fortis Bldg.
139 Water Street
St. John's, NF
A1C 1B2

Tel: (709) 726-5608
Fax: (709) 722-7373

LIST OF CONFERENCE ATTENDEES

John T. Walsh
Senior Vice-President
& Managing Director
A. HARVEY & CO. LTD.
P.O. Box 5128
St. John's, NF
A1C 5V6

Tel: (709) 726-8000
Fax: (709) 726-9891

Robert C.H. Patten
Executive
Vice-President
A. HARVEY & CO. LTD.
P.O. Box 5128
St. John's, NF
A1C 5V6

Tel: (709) 726-8000
Fax: (709) 726-9891

Clarence J. Dwyer
President
ACCORD OFFSHORE LTD.
70 Brookfield Road
P.O. Box 2446
St. John's, NF
A1C 6E7

Tel: (709) 364-8067
Fax: (709) 368-1337

Reynald Couillard
Vice-President
ACIER GENDRON LTEE
2270 Garneau
Longueuil, Quebec
J4G 1E7

Tel: (514)-527-9541
Fax: (514) 674-9867

Serge Gendron
President
ACIER GENDRON LTEE
2270 Garneau
Longueuil, Quebec
J4G 1E7

Tel: (514) 527-9541
Fax: (514) 674-9867

Robert Gill
ACRES INTERNATIONAL
Box 13337, Stn. A
St. John's, NF
A1B 4B7

Tel: (709) 754-1710
Fax: (709) 754-2717

Norman Lucas
President
AIR-TITE SHEET
METAL LTD.
P.O. Box 8221, Stn. A
St. John's, NF
A1B 3N4

Tel: (709) 726-7007
Fax: (709) 738-1071

Paul Lannon
Sales Manager,
Nfld & Labrador
AIR NOVA
Suite 940, Cabot Place
100 New Gower Street
St. John's, NF
A1A 4G7

Tel: (709) 576-8998
Fax: (709) 576-2236

Daniel Lebeau
Sales & Marketing
AKSTEL INC.
555 D'Auvergne
Longueuil, Quebec
J4H 4A3

Tel: (514) 646-2205
Fax: (514) 651-3400

Robery H. Kay
Director
ALCAN OFFSHORE
Chalfont Park
Gerrards Cross
Buckinghamshire
SL9 0QB, England

Tel: (0753) 887373
Fax: (0753) 881324

Gerry Begley
President
ALFA-LAVAL LIMITED
101 Milner Avenue
Scarborough, Ontario
M1S 4S6

Ron Legge
Branch Manager
ARROW CONSTRUCTION
PRODUCTS LTD.
P.O. Box 13038
St. John's, NF
A1B 3V8

Tel: (709) 722-0404
Fax: (709) 722-3847

Lloyd Meunier
Branch Manager
ARROW CONSTRUCTION
PRODUCTS LTD.
P.O. Box 13038
St. John's, NF
A1B 3V8

Tel: (709) 722-0404
Fax: (709) 722-3847

R.G. Halliday
Secretary/Treasurer
ATLANTIC AIRWAYS
P.O. Box 9460
St. John's, NF
A1A 2Y4

Tel: (709) 576-1800
Fax: (709) 576-1802

Ivan Palmer
President
ATLANTIC CONSULTING
ECONOMISTS LTD.
P.O. Box 2425, Stn. C
St. John's, NF
A1B 2L5

Tel: (709) 722-3112
Fax: (709) 579-1636

Todd McQuinn
Operations Manager
ATLANTIC SPEEDY
PROPANE
909 Champlain
St. Dieppe, NB
E1C 8P9

Tel: (506) 857-9901
Fax: (506) 853-8187

John Morrisey
Commercial & Industrial
Division
ATLANTIC SPEEDY
PROPANE
909 Champlain
St. Dieppe, NB
E1C 8P9

Tel: (506) 857-9901
Fax: (506) 853-8187

Joan B. Stone
AVALON COMMUNITY
COLLEGE
50 Parade Street
St. John's, NF
A1C 4C7

Tel: (709) 739-0594
Fax: (709) 739-7822

Roger Ricketts
AVESTA STAINLESS
835 Selkirk
Pt. Claire, Quebec
H9R 3S2

Tel: (514) 694-6683

H. Hendrikx
Manager of Projects
B.A.M.
P.O. Box 580
Schiedam,
The Netherlands
3100 AN

Tel: 010-31-10-4279332
Fax: 010-31-10-4279333

C.M. van Damme
Managing Director
Offshore
B.A.M.
P.O. Box 580
Schiedam
The Netherlands
3100 AN

Tel: 010-31-10-4279332
Fax: 010-31-10-4279333

Bob Tilley
Vice-President
BAINE JOHNSTON
INSURANCE LIMITED
P.O. Box 5367
St. John's, NF
A1C 5W2

Tel: (709) 576-1600
Fax: (709) 576-1739

Ian Campbell
President
BAINE JOHNSTON
INSURANCE LIMITED
P.O. Box 5367
St. John's, NF
A1C 5W2

Tel: (709) 576-1600
Fax: (709) 576-1739

Wayde Guinchard
Manager, International
Trade Services
BANK OF NOVA SCOTIA
Commercial Banking
Centre & Main Branch
245 Water Street
St. John's, NF
A1C 1B5

Tel: (709) 576-6000
Fax: (709) 726-9498

Robert Slaymaker
Vice-President
Corporate Banking
BARCLAYS BANK OF
CANADA
304 Bay Street
Toronto, Ontario
M5H 2P2

Tel: (416) 359-8000

Greg Alford
Senior Vice President
Corporate Affairs
BEAR HEAD INDUSTRIES
LTD.
Suite 908, 350 Sparks St.
Ottawa, Ontario
K1R 7S8

Tel: (613) 563-3321
Fax: (613) 563-7648

Mike Claydon
Sales Area Manager
BELLELI S.P.A.
Via Taliercio, 1
Mantova, Italy
46100

Tel: (0376) 333519
Fax: (0376) 374476

Gerry Bishop
President
BFL CONSULTANTS LTD.
133 Crosbie Road
P.O. Box 12070
St. John's, NF
A1B 3T5

Tel: (709) 753-6252
Fax: (709) 739-5458

Peter Crocker
Project Manager
BFL CONSULTANTS LTD.
133 Crosbie Road
P.O. Box 12070
St. John's, NF
A1B 3T5

Tel: (709) 753-6252
Fax: (709) 739-5458

Glen Forbes
Vice-President, Finance
BFL CONSULTANTS LTD.
133 Crosbie Road
P.O. Box 12070
St. John's, NF
A1B 3T5

Tel: (709) 753-6252
Fax: (709) 739-5458

Matt Matlock
General Manager
B.G. SPIN-TECH INC.
8110 Davies Road
Edmonton, Alberta
T6E 4N2

Tel: (403) 469-7322
Fax: (403) 469-7437

Karen Azinger
Manager Planing &
Evaluation
BHP PETROLEUM
(NEW VENTURES) INC.
5847 San Felipe
Suite 3600
77057

Tel: (713) 780-5140
Fax: (713) 780-5172

Terry Pardy
BLACK & MCDONALD
(NFLD) LTD.
P.O. Box 13608, Stn.A
St. John's, NF
A1B 4G1

Tel: (709) 782-8403
Fax: (709) 782-8020

Larry Myers
BLACK & MCDONALD
LIMITED
617 Windmill Road
Dartmouth, NS
B3B 1B6

Tel: (902) 465-3101
Fax: (902) 465-7688

Hugh McLelan
BMS OFFSHORE
617 Windmill Road
Dartmouth, NS
B3B 1B6

Tel: (902) 465-3101
Fax: (902) 465-7688

Paul J. Adams
Managing Director
BOOM CONSTRUCTION &
ENGINEERING LIMITED
P.O. Box 9245
St. John's, NF
A1A 2X9

Tel: (709) 753-8351
Fax: (709) 738-2930

Ray Stoodley
President
BUILDING SYSTEMS DESIGN
LTD.
P.O. Box 13963
St. John's, NF
A1B 4G8

Tel: (709) 579-5805
Fax: (709) 579-5520

Olav L. Mogensen
Principal Surveyor for
Canada
BUREAU VERITAS
1206, 360 St. Jacques
Montreal, Quebec
H2Y 1R5

Tel: (514) 288-6515
Fax: (514) 288-9471

Wesley Foote
Instructor Petroleum
Engineering Technology
CABOT INSTITUTE
P.O. Box 1693
St. John's, NF
A1C 5P7

Tel: (709) 778-2540
Fax: (709) 778-2277

John MacIsaac
Instructor, Petroleum
Technology
CABOT INSTITUTE
P.O. Box 1693
St. John's, NF
A1C 5P7

Tel: (709) 778-2540
Fax: (709) 778-2277

Everett Cross
CABOT INSTITUTE
1 Prince Philip Drive
P.O. Box 1693
St. John's, NF
A1C 5P7

Tel: (709) 778-2203
Fax: (709) 778-2590

Paul Adlakha
Marketing Manager -
Energy
CANADIAN MARCONI
COMPANY
415 Legget Drive
P.O. Box 13330
Kanata, Ontario
K2K 2B2

Tel: (613) 592-6500
Fax: (613) 592-7427

Charles Gautier
Project Engineer
CANARCTIC SHIPPING
COMPANY LIMITED
350 Sparks Street
Suite 1005
Ottawa, Ontario
K1R 7S8

Tel: (613) 234-9747

Dr. Jack I. Clark
Director
C-CORE
Memorial University of
Newfoundland
St. John's, NF A1B 3X5

Tel: (709) 737-8350
Fax: (709) 737-4706

John Fitzgerald
Vice-Chairman
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1452
Fax: (709) 778-1473

Judith McIntyre
Geophysicist
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1424
Fax: (709) 778-1473

Riaz A. Chaudhry
Manager Exploration
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
4th Floor, TD Place
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1419
Fax: (709) 778-1473

Wayne I. Chipman
Manager Reservoir
Engineering
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1428
Fax: (709) 778-1473

Frank Smyth
Senior Benefits Manager
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
5th Floor, TD Place
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1439
Fax: (709) 778-1473

David Burley
Senior Environmental
Officer
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
5th Floor, TD Place
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1400
Fax: (709) 778-1473

Bill Hickey
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
5th Floor, TD Place
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1400
Fax: (709) 778-1473

Ted O'Keefe
CANADA-
NEWFOUNDLAND
OFFSHORE PETROLEUM
BOARD
140 Water Street
St. John's, NF
A1C 6H6

Tel: (709) 778-1400
Fax: (709) 778-1473

Wayne Bussey
President
CANADIAN CENTRE
FOR MARINE
COMMUNICATIONS
P.O. Box 8454
St. John's, NF
A1B 3N9

Tel: (709) 579-4872
Fax: (709) 579-0495

Brian Whitehouse
Busines Development
CANADIAN CENTRE
FOR MARINE
COMMUNICATIONS
P.O. Box 8454
St. John's, NF
A1B 3N9

Tel: (709) 579-4872
Fax: (709) 579-0495

Ronald Newhook
Business Development
Officer
CANADIAN CENTRE
FOR MARINE
COMMUNICATIONS
P.O. Box 8454
St. John's, NF
A1B 3N9

Tel: (709) 579-4872
Fax: (709) 579-0495

Kenneth Ryan
CANADIAN COAST GUARD
382 Lefebvre Way
Orleans, Ontario
K1E 2W4

Tel: (613) 991-3163

G. Gerald Valgora
Vice-President/
General Manager
CANADIAN METAL
ROLLING MILLS, A DIVISION
OF SAMUEL MANU-TECH
INC.
2304 Dixie Road
Mississauga, Ontario
L4Y 1Z6

Tel: (416) 270-5300
Fax: (416) 270-8221

Dr. Z.M. Meralta
CDS RESEARCH LTD.
Suite 100
565-17th Street
West Vancouver, BC
V7V 3S9

Tel: (604) 925-2860
Fax: (604) 925-2861

Mac Moss
Principal
CENTRAL NFLD
COMMUNITY COLLEGE
Box 395
Gander, NF
A1V 1W8

Tel: (709) 256-4481
Fax: (709) 651-3376

Christine Fagan
CHALKER, GREEN & ROWE
P.O. Box 5939
St. John's, NF
A1C 5X4

Tel: (709) 722-8735
Fax: (709) 722-1763

Gil Thibeau
CHECO NATIONAL
CANADIAN VENTURE
Suite 603, TD Place
St. John's, NF
A1C 5W1

Tel: (709) 722-5606

Jean Cormier
CHECO NATIONAL
CANADIAN VENTURE
Suite 603, TD Place
St. John's, NF
A1C 5W1

Tel: (709) 722-5606

Bob Britton
CHECO NATIONAL
CANADIAN VENTURE
Suite 603, TD Place
St. John's, NF
A1C 5W1

Tel: (709) 722-5606

John Jabara
CHECO NATIONAL
CANADIAN VENTURE
Suite 603, TD Place
St. John's, NF A1C 5W1

Tel: (709) 722-5606

John F. Krokosh
President
CHAMPION
NORTHWESTERN
CHEMICALS LTD.
830-550-6th Avenue S.W.
Calgary, Alberta
T2P 0S2

Tel: (403) 234-7881

Charles Hainbach
President
CHAMPION
TECHNOLOGIES INC.
1722 Scenic Shore Dr.
Kingwood, Texas
77345

Jack Roberson
CHAMPION TECH.
830-550-6th Avenue S.W.
Calgary, Alberta
T2P 0S2

Jerry King
CHEVRON CANADA
RESOURCES
500, 5th Avenue S.W.
Calgary, Alberta
T2P 0L7

Tel: (403) 234-5294
Fax: (403) 234-5979

Russell Yates
CLANDON CONSULTANCY
Longoaks
Pennymead Drive
East Horsley
Surrey, UK
KT24 5AH

Tel: (04865) 3831

Austin Burry
CLARENVILLE DRYDOCK
LTD.
P.O. Box 147
Clarenville, NF
A0E 1J0

Tel: (709) 466-7725
Fax: (709) 466-7454

Jean-Michel Dumay
Executive Vice-President
COFLEXIP & SERVICES INC.
7660 Woodway
Suite 390
Houston, Texas 77063

Tel: (713) 789-8540
Fax: (713) 789-7367

Lawnie A. Sturdevant
Manager of Sales &
Marketing
COFLEXIP & SERVICES INC.
7660 Woodway
Suite 390
Houston, Texas
77063

Tel: (713) 789-8540
Fax: (713) 789-7367

Bill Burch
Partner
COOPERS & LYBRAND
Suite 702
235 Water Street
St. John's, NF
A1C 1B6

Tel: (709) 722-3883
Fax: (709) 722-5874

Lewis Stoyles
Principal, Special Services
COOPERS & LYBRAND
235 Water Street
St. John's, NF
A1C 1B6

Tel: (709) 722-3883
Fax: (709) 722-5874

Dennis Young
Manager
THE COOPERS & LYBRAND
CONSULTING GROUP
Suite 702
235 Water Street
St. John's, NF
A1C 1B6

Tel: (709) 722-3883
Fax: (709) 722-5874

Flemming Crawfurd
Danish Trade
Commissioner
DANISH CONSULATE
151 Bloor West
Suite 310
Toronto, Ontario
M5S 1S4

Fax: (416) 962-3668

Walter Charette
Ocean Freight Manager
DANZAS (CANADA) LTD.
455 Boul. Fenelon
Suite 200
Dorval, Quebec
H9S 5T8

Tel: (514) 633-5909
Fax: (514) 633-5910

David Street
President
D.A.S. METAL PRODUCTS
INC.
80 Bullock Drive
Unit 8
Markham, Ontario
L3P 3P7

Tel: (416) 471-6050
Fax: (416) 471-0141

Jean-Yves Bergel
DEGREMONT INFILCO LTD.
160 D St. Joseph Blvd.
Quebec
H8S 2L3

Tel: (514) 634-8011
Fax: (514) 634-3102

Leon O'Quinn
DEPT OF DEVELOPMENT
INDUSTRIAL TECHNOLOGY
DIVISION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5592
Fax: (709) 729-5936

Bob Robinson
DEPT OF DEVELOPMENT
INDUSTRIAL TECHNOLOGY
DIVISION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5592
Fax: (709) 729-5936

Linda Spurrell
DEPT OF DEVELOPMENT
INDUSTRIAL TECHNOLOGY
DIVISION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5592
Fax: (709) 729-5936

Brian McShane
DEPT OF DEVELOPMENT
INDUSTRIAL TECHNOLOGY
DIVISION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5592
Fax: (709) 729-5936

Terry Johnstone
DEPT OF DEVELOPMENT
INDUSTRIAL TECHNOLOGY
DIVISION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5592
Fax: (709) 729-5936

Jeanette Woodman
DEPT OF DEVELOPMENT
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5592
Fax: (709) 729-5936

Paul Alexander
Director
DEPT OF DEVELOPMENT
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5064
Fax: (709) 729-5936

Darrell O'Neill
DEPT OF DEVELOPMENT
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5064
Fax: (709) 729-5936

Fintan Costello
Assistant Director
DEPT. OF EDUCATION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5760
Fax: (709) 729-5896

Arthur Leung
Program Consultant
DEPT. OF EDUCATION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5760
Fax: (709) 729-5876

Carolyn Bennett
DEPT. OF EDUCATION
P.O. Box 4750
St. John's, NF
A1C 5T7

Tel: (709) 729-5666
Fax: (709) 729-5896

Margo Dobbin
Program Consultant
DEPT. OF EDUCATION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5760
Fax: (709) 729-5896

M.L. Mandville
DEPT. OF EDUCATION
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5760
Fax: (709) 729-5896

Jerry O'Brien
Senior Project Executive
DEPT. OF COMMERCE &
TECHNOLOGY
P.O. Box 6000
670 King Street
Fredericton, NB
E3B 5H1

Tel: (506) 453-2102
Fax: (506) 457-4845

Catherine Gogan
Assistant Deputy Minister
DEPT. OF EMPLOYMENT &
LABOUR RELATIONS
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-5674
Fax: (709) 729-6639

Pat Laracy
DEPT. OF MINES & ENERGY
P.O. Box 8700
St. John's, NF
A1B 4J6

Lorne Spracklin
Assistant Deputy Minister
DEPT. OF MINES & ENERGY
6th Fl., Atlantic Pl.
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2348
Fax: (709) 729-2508

Charles W. Bown
Energy Economist
DEPT. OF MINES & ENERGY
6th Fl., Atlantic Pl.
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2459
Fax: (709) 729-2508

Bill Mullaly
DEPT. OF MINES & ENERGY
6th Fl., Atlantic Pl.
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-4363
Fax: (709) 729-2508

Charles S. Lester
Director, Policy & Planning
& Coordinations
DEPT. OF MINES & ENERGY
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2339
Fax: (709) 729-2508

Barry Rodgers
DEPT. OF MINES & ENERGY
6th Fl., Atlantic Pl.
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-3674
Fax: (709) 729-2508

David W. Hawkins
Director, Petroleum
Resource Devel.
DEPT. OF MINES & ENERGY
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2323
Fax: (709) 729-2305

R. Gordon Gosse
Deputy Minister
DEPT. OF MINES & ENERGY
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2356
Fax: (709) 729-0059

Hon. Dr. Rex Gibbons
Minister
DEPT. OF MINES & ENERGY
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2920
Fax: (709) 729-0059

Susan Hollett
Executive Assistant to the Minister
DEPT. OF MINES & ENERGY
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2920
Fax: (709) 729-0059

Martin Sheppard
Assistant Deputy Minister
DEPT. OF MINES & ENERGY
6th Floor, Atlantic Place
215 Water Street
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 729-2349
Fax: (709) 729-2508

John P. Beyak
Sales Engineer
DRESSER RAND CANADA INC.
Unit 13
3397 American Drive
Mississauga, Ontario
L4V 1T8

Tel: (416) 677-8610
Fax: (416) 677-0546

Ewan R. Orr
Vice-President
Atlantic Region
DRUMMOND MCCALL
P.O. Box 910
Armdale, NS B3L 4L1

Tel: (902) 876-7861
Fax: (902) 876-8455

Thomas Kendall
President
EASTCAN INTERNATIONAL INC.
P.O. Box 8056
St. John's, NF
A1B 3M7

Tel: (709) 579-8650
Fax: (709) 579-1282

Brian Delaney
ECONOMIC RESEARCH & ANALYSIS, DIVISION OF EXECUTIVE COUNCIL
6th Fl., East Block
Confederation Bldg.
P.O. Box 8700
St. John's, NF
A1B 4J6

Tel: (709) 576-3256
Fax: (709) 576-6944

Stuart Rodgers
Managing Director
EIFFEL (UK) LTD.
Kingswick House
Kingswick Drive
Sunninghill, Berks
England SL578H

Tel: (0344) 23491
Fax: (0344) 26176

J.S. Ellett
ELLETT COPPER & BRASS
1575 Kingsway Avenue
Port Coquitlam
V7T 1W9

Tel: (604) 941-8211
Fax: (604) 941-7669

Andre Paquin
Economist
ENERGY, MINES & RESOURCES CANADA
580 Booth Street
Ontario

Tel: (613) 996-3213
Fax: (613) 996-7837

Denis Zborowski
ENERGY, MINES & RESOURCES CANADA
355 River Road
Tower B, 16th Floor
Ottawa, Ontario
K1A 0E4

Tel: (613) 991-1915
Fax: (613) 993-9897

Susan McLaughlin
Project Monitoring Officer
ENERGY, MINES & RESOURCES CANADA
580 Booth Street
Room 1706
Ottawa, Ontario
K1A 0E4

Tel: (613) 996-7307
Fax: (613) 996-7837

Dan Ferguson
ENERGY, MINES & RESOURCES CANADA
Box 65, Atlantic Pl.
215 Water Street
St. John's, NF
A1C 6C9

Tel: (709) 772-4213
Fax: (709) 772-5659

Blaine Gillis
Director, Equity Investments & Dev.
ENTERPRISE CAPE BRETON CORP.
P.O. Box 1750
Sydney, NS
B1P 6T7

Tel: (902) 564-3602

Derek McDonald
Marine Environmental
Engineer
ENVIRONMENT CANADA
Queen Square
45 Alderney Drive
Dartmouth, NS
B2Y 2N6

Tel: (902) 426-6892
Fax: (902) 426-9709

Sheila Smith
Partner
ERNST & YOUNG
Baine Johnston Centre
7th Floor
10 Fort William Place
St. John's, NF
A1C 1K4

Tel: (709) 726-2840
Fax: (709) 726-0345

David J. Oake
Assistant Secretary of the
Cabinet
EXECUTIVE COUNCIL,
PROVINCIAL GOVT.
7th Floor, East Block
Confederation Bldg.
St. John's, NF
A1B 4J6

Tel: (709) 729-2845
Fax: (709) 729-5218

Eric Gibbs
FABCO INDUSTRIES
Halifax, NS

Tel: (902) 468-3222

Raymond P. walsh
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St. John's, NF
A1B 4B4

Tel: (709) 753-6351
Fax: (709) 753-6129

Olavi Kangas
Manager, Business
Development
FINNSTEEL INC.
5 Revere Drive
Suite 502
Northbrook, IL
60062

Tel: (708) 480-0420
Fax: (708) 480-9466

Wayne Ash
FOLLETT, GOSSE &
ASSOCIATES LTD.
P.O. Box 9485
St. John's, NF
A1A 2Y4

Tel: (709) 753-2100
Fax: (709) 753-7011

Daniel Desjardins
Sales Manager
FRANCOSTEEL CANADA
INC.
5890 Monkland Avenue
#303
Montreal, Quebec
H4A 1G2

Tel: (514) 489-8458
Fax: (514) 489-7227

Fred Cahill
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LTD.
P.O. Box 1674
St. John's, NF
A1C 5P5

Tel: (709) 368-2125
Fax: (709) 368-3502

William Barclay
CAHILL-STATE-
BALFOURKILPATRICK
P.O. Box 1674
St. John's, NF
A1C 5P5

Al Fabian
CAHILL-STATE-
BALFOURKILPATRICK
P.O. Box 1674
St. John's, NF
A1C 5P5

Jonathan Taylor
CAHILL-STATE-
BALFOURKILPATRICK
P.O. Box 1674
St. John's, NF
A1C 5P5

Jim Milne
President
G.M.I.
71 Ilsley Avenue
Unite 6
Dartmouth, NS
B3B 1L5

Tel: (902) 468-1261
Fax: (902) 468-3855

John Dartnall
CEO
G.M.I.
71 Ilsley Avenue
Unit 6
Dartmouth, NS
B3B 1L5

Tel: (902) 468-1261
Fax: (902) 468-3855

Carl Granter
President
GEOMETRICS
P.O. Box 2516, Stn. C
St. John's, NF
A1C 6K1

Tel: (709) 739-8718
Fax: (709) 739-1538

Judy English
President
GIRL FRIDAY LTD.
St. John's, NF

Tel: (709) 579-3400

Gary LeRoux
Senior Consultant
GOVT CONSULTANTS
INTERNATIONAL
50 O'Connor Street
Suite 1300
Ottawa Ontario
K1P 6L2

Tel: (613) 236-3496

Pierre Marquis
Regional Manager,
Business Expansion
GROUPE LAPERRIERE &
VERREAULT INC. (GL&V)
220 Brunswick Blvd.
Pte Claire, Quebec
H9R 1A6

Tel: (514) 630-7944
Fax: (514) 630-7947

Michel Lafrance
Plate Chief Metallurgist
GTS INDUSTRIES
Rue du Comte Jean
59760 Grande-Synthe
B.P. 6317
59379 Dunkerque
Cedex 1, France

Tel: 28 29 37 00
Fax: 28 29 37 28

Jean-Michel Vigo
Product Manager
GTS INDUSTRIES
Rue du Comte Jean
59760 Grande-Synthe
B.P. 6317
59379 Dunkerque
Cedex 1, France

Tel: 28 29 31 56
Fax: 28 29 37 28

Ralph Amato
President
GUIDE VALVE SUPPLY
(QUEBEC) LTD.
207 Place Frontenac
Pte Claire, Quebec
H9R 4Z7

Tel: (514) 695-9250

Gerry Germain
President
GENERGY INC.
P.O. Box 13745, Stn. A
St. John's, NF
A1B 4G3

Tel: (709) 782-0016
Fax: (709) 782-0025

Patrick Depardon
Vice President Sales
GTS INDUSTRIES
Cedex 34
Paris La Defense
France 92072

Tel: 47 67 83 46

Bill Pollock
Marketing Representative
HALIFAX-DARTMOUTH
INDUSTRIES
P.O. Box 1477
Halifax, NS
B3K 5H7

Tel: (902) 423-9271
Fax: (902) 422-5253

Mike Apostolidis
Manager, Industrial
Projects
HALIFAX-DARTMOUTH
INDUSTRIES
P.O. Box 1477
Halifax, NS
B3K 5H7

Tel: (902) 423-9271
Fax: (902) 422-5253

Andrew A. McArthur
President & CEO
HALIFAX-DARTMOUTH
INDUSTRIES
P.O. Box 1477
Halifax, NS
B3K 5H7

Tel: (902) 423-9271
Fax: (902) 422-5253

Harry Clark
Vice President, Special
Projects & Development
HALIFAX-DARTMOUTH
INDUSTRIES LTD.
P.O. Box 1477
Halifax, NS
B3K 5H7

Tel: (902) 423-9271
Fax: (902) 422-5253

Arthur J. Maw
Regional Manager
HANSCOMB CONSULTANTS
INC.
238 Blackmarsh Road
St. John's, NF
A1E 1T2

Tel: (902) 722-0505
Fax: (902) 722-1504

Mark Outerbridge
Vice-President
HARVEY GROUP OF
COMPANIES
P.O. Box 8220, Stn. A
St. John's, NF
A1B 3N6

Tel: (709) 722-6910
Fax: (709) 739-0924

Jim Kenny
Executive Director
HIBERNIA EMPLOYERS'
ASSOCIATION
WestBrook Plaza
860-866 Topsail Road
Mount Pearl, NF
A1N 3J7

Tel: (709) 747-1755
Fax: (709) 747-1758

Ian Denness
HIBERNIA MANAGEMENT &
DEVELOPMENT COMPANY
LTD.
7777 Decarie Blvd.
Montreal, Quebec
H4P 2S6

Tel: (514) 345-6528
Fax: (514) 345-0196

Leroy Nigh
Business Development
Manager
HORTON CBI LIMITED
P.O. Box 601
Fort Erie, Ontario
L2A 5N4

Tel: (416) 871-1500
Fax: (416) 871-6341

E.J. Vromen
Marketing Manager
H.S.M.
P.O. Box 580
Schiedam
The Netherlands
3100 AN

Tel: 010-31-10-4279332
Fax: 010-31-10-4279333

J. van Benthem
Architect
H.T.V.
P.O. Box 580
Schiedam
The Netherlands 3100 AN

Tel: 010-31-10-4279332
Fax: 010-31-10-4279333

Gaston Langlois
Business Development
HYDRO-MECANIQUE
CONSTRUCTION INC.
1451 Graham Bell
Boucherville, Quebec
J4B 6A1

Tel: (514) 449-3999
Fax: (514) 449-3564

Dr. C.S. Ahn
Senior Vice-President
HYUNDAI HEAVY
INDUSTRIES CO. LTD.
75 Frontenac Drive
Markham, Ontario
L3R 6H2

Tel: (416) 477-0101
Fax: (416) 477-3983

D.S. Cho
Manager
HYUNDAI HEAVY
INDUSTRIES CO. LTD.
75 Frontenac Drive
Markham, Ontario
L3R 6H2

Tel: (416) 477-0101
Fax: (416) 477-3983

Tim Hopkins
Manager
I.H. MATHERS & SON LTD.
P.O. Box 5668
St. John's, NF
A1C 5X8

Tel: (709) 722-4956
Fax: (709) 722-5350

Bernard Prevost
General Manager
I.H. MATHERS & SON LTD.
P.O. Box 5668
St. John's, NF
A1C 5X8

Tel: (709) 722-4956
Fax: (709) 722-5350

Stephen Henley
Vice President
Marketing/Corporate
Relations
INDUSTRIAL RESEARCH INC.
Suite 940, Cabot Pl.
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 738-1515
Fax: (709) 738-1210

Anne Mills
Vice President/
Public Affairs
INDUSTRIAL RESEARCH INC.
Suite 940, Cabot Pl.
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 738-1515
Fax: (709) 738-1210

Ronald Bowers
President
INDUSTRIAL RESEARCH INC.
Suite 940, Cabot Pl.
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 738-1515
Fax: (709) 738-1210

Frank Nolan
Executive Director
INDUSTRY, SCIENCE &
TECHNOLOGY CANADA
P.O. Box 8950
St. John's, NF
A1B 3R9

Tel: (709) 772-4866
Fax: (709) 772-5093

Patricia Hearn
Director
INDUSTRY, SCIENCE &
TECHNOLOGY CANADA
P.O. Box 8950
St. John's, NF
A1B 3R9

Tel: (709) 772-4793
Fax: (709) 772-5093

N.E. Jeffrey
Director General
INSTITUTE FOR MARINE
DYNAMICS
P.O. Box 12093, Stn. A
St. John's, NF A1B 3T5

Tel: (709) 772-2469
Fax: (709) 772-2462

Mark Staple
President
IMS GROUP INC.
Suite 630, Cabot Pl.
St. John's, NF
A1C 6K3

Tel: (709) 579-5492
Fax: (709) 579-2099

Bill Andrews
Senior Adviser Hibernia
INDUSTRY, SCIENCE &
TECHNOLOGY CANADA
235 Queen Street
Ottawa, Ontario
K1A 0H5

Tel: (613) 954-3430

Gar Beauchesne
Sales Manager
INGERSOL FASTNERS
P.O. Box 40
Ingersoll, Ontario
N5C 3K3

Tel: (519) 485-4610
Fax: (519) 485-2435

Gisele E. Le Moaligou
Director
IN-SPEC MANPOWER &
INSPECTION SERIVCES
Haig House
15 Young Street
London
W85EH, G.B.

Tel: 071-937-2801
Fax: 071-937-5773

Lee Shinkle
President
INSTRUMAR LIMITED
25 Pippy Place
P.O. Box 13246, Stn. A
St. John's, NF
A1B 4A5

Tel: (709) 772-6001
Fax: (709) 772-2462

R. Squires
Nfld Branch Manager
ITT FLYGT
P.O. Box 7
St. John's, NF
A1C 5H5

Tel: (709) 722-9832
Fax: (709) 722-6717

Michael Wimmer
National Sales Manager
ITT FLYGT
300 Labrosse Avenue
Pte Claire, Quebec
H9R 4V5

Tel: (514) 695-0100
Fax: (514) 694-6798

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President
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P.O. Box 8160
St. John's, NF
A1B 3N3

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Fax: (709) 722-6975

Geoffrey H. Monn
President
J.W. BIRD & COMPANY
LTD.
P.O. Box 1090
Fredericton, NB
E3B 5C6

Tel: (506) 453-9915

Tony McGrath
Branch Manager
JOHNSON CONTROLS LTD.
P.O. Box 8393, Stn. A
St. John's, NF
A1B 3N7

Tel: (709) 579-5565
Fax: (709) 579-9015

Larry D. Edgar
Project Procurement
Coordinator
LASMO NOVA SCOTIA
LIMITED
Suite 1400, Founders Sq.
1701 Hollis Street
Halifax, NS
B3J 3M8

Tel: (902) 422-4500
Fax: (902) 425-2766

Bevin LeDrew
President
LEDREW, FUDGE &
ASSOCIATES LTD.
P.O. Box 9370
St. John's, NF
A1A 2Y3

Tel: (709) 576-1458
Fax: (709) 576-2126

Mike Strong
President
M.S. MARINE SERVICES
283 Airport Heights Dr.
St. John's, NF
A1A 4X9

Tel: (709) 722-3303

Kens Dons
MARCONI SIMULATION
Napier Bldg.
Dunfermline
Fife, Scotland
KY11 5J2

Tel: 44-383-822131
Fax: 44-383-829227

Daniel Wong
Division Head
MARINE INSTITUTE
P.O. Box 4920
St. John's, NF
A1C 5R3

Tel: (709) 778-0541
Fax: (709) 778-0346

Wally Jacobs
Co-Ordinator
MEMORIAL UNIVERSITY
Division of Co-op
Education
St. John's, NF
A1B 3X5

Tel: (709) 737-8816
Fax: (709) 737-4042

Peter V. Young
Director
MEMORIAL UNIVERSITY
Division of Co-op
Education
S.J. Carew Bldg.
Room X4021
St. John's, NF
A1B 3X5

Tel: (709) 737-8815
Fax: (709) 737-4051

Scott R. Spidell
Special Projects
Development
MIDLAND TRANSPORT
LIMITED
P.O. Box 929
Moncton, NB E1C 8N8

Tel: (506) 858-5555
Fax: (506) 856-7762

Paul Gulyas
Vice-President
Commercial
MIL SYSTEMS ENGINEERING
INC.
1600 Carling Avenue
Ottawa, Ontario
K1Z 8R7

Tel: (613) 722-2247
Fax: (613) 722-3505

Jean R. Hemond
MINISTERE INDUSTRIE
COMMERCE &
TECHNOLOGIE DU QUEBEC
710 Place D'Youville
5th Floor
Quebec, QC
G1R 4Y4

Tel: (418) 691-5956
Fax: (418) 643-6669

Pierre Fitzgerald
Sector Manager
MINISTERE INDUSTRIE,
COMMERCE &
TECHNOLOGIE DU QUEBEC
710 Place D'Youville
5th Floor
Quebec, QC
GiR 4Y4

Tel: (418) 691-5956
Fax: (418) 643-6669

Moya Cahill
President
MNC CONSULTANTS
Suite 790, Cabot Pl.
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 754-9013
Fax: (709) 754-4704

Jim A. Kelly
MOBIL OIL CANADA
PROPERTIES
P.O. Box 800
Calgary, Alberta
T2P 2J7

Tel: (403) 260-4284
Fax: (403) 260-7101

Frank Dello Stritto
Ocean Environment
Group Leader
MOBIL RESEARCH &
DEVELOPMENT CORP.
13777 Midway Road
Dallas, Texas 75244

Tel: (214) 851-8324
Fax: (214) 851-8349

Roy Myers
President
MYERS CONSULTING
P.O. Box 14029
St. John's, NF
A1B 4G8

Tel: (709) 754-3300
Fax: (709) 754-6233

Bob Byrne
Sales Representative
NATIONAL OILWELL
CANADA LTD.
P.O. Box 338
Mount Pearl, NF
A1N 2C3

Tel: (709) 364-2361
Fax: (709) 364-6903

Kenneth F. Reeder
Vice-President & General
Manager
NEILL & GUNTER LIMITED
P.O. Box 713
Fredericton, NB
E3B 5B4

Tel: (506) 452-7000
Fax: (506) 452-0112

Lars Aarrestad
Operations Manager
NEWFOUNDLAND
ASSURANCE OF QUALITY
P.O. Box 433
St. John's, NF
A1C 5K4

Tel: (709) 579-0957
Fax: (709) 579-9842

Gerry Awde
President
NEWMAN'S VALVE LIMITED
P.O. Box 881
Barry, Ontario
L4M 3S3

Derek Hood
National Sales Manager
NEWMAN'S VALVE LIMITED
P.O. Box 881
Barry, Ontario
L4M 3S3

Frank A. Sommerville
NOVA SCOTIA DEPT. OF
INDUSTRY, TRADE &
TECHNOLOGY
P.O. Box 519
Halifax, NS
B3J 2R7

Paul Green
President
NEWFOUNDLAND
GEOSCIENCES LIMITED
P.O. Box 9370, Stn. B
607 Torbay Road
St. John's, NF
A1A 2Y3

Tel: (709) 576-1428
Fax: (709) 675-2126

Marilyn Staple
Marketing Manager
NFLD & LABRADOR
HOUSING CORPORATION
P.O. Box 220
St. John's, NF A1C 5J2

Tel: (709) 745-0281
Fax: (709) 745-2388

David Burnell
Managing Director
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P.O. Box 8940
St. John's, NF A1B 3S2

Tel: (709) 722-5660
Fax: (709) 722-2290

Nath J. Cooper
President
NEWOCEAN
CONTRACTORS LIMITED
P.O. Box 5128
87 Water Street
St. John's, NF
A1C 5V6

Tel: (709) 754-4813
Fax: (709) 726-9891

Matthew Loh
Project Manager
NEWOCEAN
CONTRACTORS LIMITED
P.O. Box 5128
87 Water Street
St. John's, NF
A1C 5V6

Tel: (709) 754-4813
Fax: (709) 726-9891

G.C. Robertson
GBS Planner
NODECO
66 Kenmount Road
St. John's, NF
A1C 6E7

Tel: (709) 758-4046

Cabot Martin
Director
NEW OCEAN CONCEPTS
INC.
P.O. Box 5580
St. John's, NF
A1C 5W4

Tel: (709) 579-5050
Fax: (709) 579-1497

Theis Ulrichson
NORWEGIAN TRADE
COUNCIL
Drammensveiyo 0255
Oslo 2, Norway

Jan Aagenaes
Consul & Trade
Commissioner
NORWEGIAN TRADE
COUNCIL
1200 Bay Street
Suite 1103
Toronto, Ontario
M5R 2A5

Tel: (416) 920-0434
Fax: (416) 920-5982

Christian Nygaard
Product Manager -
Floating Platforms
NORWEGIAN
CONTRACTORS
Holtet 45
Stabekk, Norway 1320

Tel: 47-2129090
Fax: 47-2129100

Judith Bobbitt
OCEANS LIMITED
31 Temperance Street
St. John's, NF
A1C 3J3

Tel: (709) 753-5788
Fax: (709) 753-4237

Doug Taylor
Manager Marketing &
Sales - Newfoundland
OCEANEX
P.O. Box 5097
St. John's, NF
A1C 5V3

Tel: (709) 722-6280
Fax: (709) 726-2080

Gilles Champagne
President & CEO
OCEANEX
P.O. Box 5097
St. John's, NF
A1C 5V3

Tel: (709) 722-6280
Fax: (709) 726-2080

Bruce Dyke
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INTERNATIONAL INC.
P.O. Box 13938, Stn. A
St. John's, NF
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Fax: (709) 739-5939

Per Faste Moe
Project Director
PCL-AKER STORD-STEEN-
BECKER, A JOINT VENTURE
Suite 300, Cabot Place
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 754-5816
Fax: (709) 753-7431

Claude Sheppard Jr.
Director Business Services
PCL-AKER STORD-STEEN-
BECKER, A JOINT VENTURE
Suite 300, Cabot Place
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 754-5816
Fax: (709) 753-7431

Jean Payne
PCM GROUP
P.O. Box 191
St. John's, NF
A1C 5J2

Tel: (709) 722-1200
Fax: (709) 722-1201

Morris N. Palmer
President
PALMER RANCH (1984)
LTD.
Suite 1960
McFarlane Tower
700 - 4 Avenue S.W.
Calgary, Alberta
T2P 3J4

Tel: (403) 265-2330
Fax: (403) 233-2553

G. Ian Ferguson, CMC
Principal
PEAT MARWICK
STEVENSON & KELLOGG
Suite 800, Cabot Place
100 New Gower Street
St. John's, NF
A1C 1J3

Tel: (709) 722-5804
Fax: (709) 726-3000

A. Brian Peckford
President
PECKFORD OFFSHORE -
PECKFORD
INCORPORATED
Box 102, 570 Nfld Drive
St. John's, NF
A1A 5B1

Tel: (709) 739-8267
Fax: (709) 739-6608

Bruce Shaw
PETRO-CANADA
13th Floor
150-6th Avenue S.W.
Calgary, AB T2P 3E3

Tel: (403) 296-5518
Fax: (403) 296-3030

Roy Hodgkinson
PETRO-CANADA
13th Floor
150-6th Avenue S.W.
Calgary, Alberta
T2P 3E3

Tel: (403) 296-5518
Fax: (403) 296-3030

Wayne Wetmore
Vice-President, Training &
Development
PETROLEUM INDUSTRY
TRAINING SERVICE
13, 2115-27 Avenue NE
Nisku, Alberta
T2E 7E4

Tel: (403) 250-9606
Fax: (403) 291-9408

Les Evans
PETROLEUM INDUSTRY
TRAINING SERVICE
1020-20 Avenue
Nisku, Alberta
T0E 2C0

Tel: (403) 955-7770
Fax: (403) 955-2454

William Duncan
Managing Director
POLARIS MARINE SERVICES
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108 Glencoe Drive
P.O. Box 1447
St. Johns, NF
A1C 5N8

Tel: (709) 368-1648
Fax: (709) 747-9471

Leslie Noble
President
POLITICAL &
COMMUNICATIONS
STRATEGY
55 The Esplanade #503
Toronto, ON M5E 1V2

Tel: (416) 346-1042
Fax: (416) 360-8529

John Downton
PRIME COMMUNICATIONS
P.O. Box 13305, Stn. A
St. John's, NF
A1B 4B7

Tel: (709) 754-3137
Fax: (709) 754-3138

Luke Morrison
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P.O. Box 162
Fredericton, NB
E3B 4Y9

Tel: (506) 459-1770
Fax: (506) 459-5026

Arthur Puddister
Managing Director
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P.O. Box 38, Stn. C
23 Springdale Street
St. John's, NF
A1C 5H5

Tel: (709) 722-4000
Fax: (709) 722-8008

Robert Haley
Sales Manager, North &
South America
QUALITY OILFIELD
PRODUCTS
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Houston Road
Cypress, Texas 77429

Tel: (713) 890-4011
Fax: (713) 890-5028

David Fong
President
RDS ENGINEERING LTD.
Suite 802, Fortis Bldg.
139 Water Street
St. John's, NF
A1C 1B2

Tel: (709) 739-7676
Fax: (709) 722-7373

Bob Miller
RE/MAX REALTY
SPECIALISTS LTD.
570 Newfoundland Drive
Box 101
St. John's, NF
A1A 5B1

Tel: (709) 726-8300
Fax: (709) 726-4219

Dennis C. Dunlop
Assistant Marketing & Sales
Manager
RMI TITANIUM CO.
11200 Westheimer Suite
508
Houston, Texas 77042

Tel: (713) 266-3003

John R. Schley
Manager, Technical
Marketing
RMI TITANIUM CO.
1000 Warren Avenue
Niles, Ohio
44446

Tel: (216) 544-7811

Stephen Paine
Managing Director
SAYBOLT CANADA LTD.
1 Research Drive
Suite 101
Dartmouth, NS
B2Y 4M9

Tel: (902) 464-1500
Fax: (902) 464-0999

Arthur Garland
Vice-President
SEA LIMITED
2 Dundee Avenue
Mount Pearl, NF
A1N 4R7

Tel: (709) 364-2075
Fax: (709) 364-8098

Paul Locke
President & CEO
SEABASE LIMITED
P.O. Box 5099
St. John's, NF
A1C 5V3

Tel: (709) 722-3080
Fax: (709) 722-9740

Alfred A. Smithers
President
SECUNDA MARINE
SERVICES LTD.
1 Canal Street
Dartmouth, NS
B2Y 3Y9

Tel: (902) 465-3400
Fax: (902) 465-7678

Graham Curren
Chartering Manager
SECUNDA MARINE
SERVICES LTD.
1 Canal Street
Dartmouth, NS
B2Y 3Y9

Tel: (902) 465-3400
Fax: (902) 465-7678

D.I. Jones
Director New Business
Development
SAINT JOHN SHIPBUILDING
LIMITED
P.O. Box 5111
Saint John, NB
E2L 4L4

Tel: (506) 632-3232
Fax: (506) 632-5915

Brenda Steele
Administrator
SEA CAM LIMITED
35 Blackmarsh Road
St. John's, NF
A1E 1S4

Tel: (709) 738-1327
Fax: (709) 738-3350

Victor Gameiro
Director, Business
Development
SECURIPLEX
210 Brunswick Blvd.
Pt Claire, Quebec
H9R 1A6

Tel: (514) 697-8002
Fax: (514) 697-9525

Richard Myrnes
Sales Manager
SECURIPLEX -
GINGE-KERR
210 Brunswick Blvd.
Pt. Claire, Quebec
H9R 1A6

Tel: (514) 697-8002
Fax: (514) 607-9525

Ajit S. Sodhi
President & General Mgr.
SECURIPLEX
210 Brunswick Blvd.
Pt. Claire, Quebec
H9R 1A6

Tel: (514) 697-8002
Fax: (514) 697-9525

Bert Peach
President
SHAWMONT
NEWFOUNDLAND LIMITED
P.O. Box 9600
Bally Rou Place
St. John's, NF
A1N 1R5

Tel: (709) 754-0250
Fax: (709) 739-6823

Eric Gray
Operations Manager
SHAWMONT
NEWFOUNDLAND LIMITED
P.O. Box 9600
St. John's, NF
A1A 3C1

Tel: (709) 754-0290
Fax: (709) 739-6823

Paul Molloy, P. Eng
Quality Manager
SPEC NEWFOUNDLAND
LTD.
Box 668
St. John's, NF
A1C 5L4

Tel: (709) 726-1667
Fax: (709) 726-1668

Y. Pau Woo
Manager
ST. JOHN'S BOARD OF
TRADE
P.O. Box 5127
St. John's, NF
A1C 5V5

Tel: (709) 726-2961
Fax: (709) 726-2003

Yves Delagrave
Vice President, Marketing
ST. LAWRENCE CEMENT
INC.
435 Place Trans-Canada
Longueuil, Quebec
J4G 2P9

Tel: (514) 598-8750
Fax: (514) 598-1578

Phil Pinsonneault
Director Technical Services
ST. LAWRENCE CEMENT
INC.
435 Place Trans-Canada
Longueuil, Quebec
J4G 2P9

Tel: (514) 598-8750
Fax: (514) 598-1578

Jean-Jacques Perron
Distribution Manager
ST. LAWRENCE CEMENT
INC.
435 Place Trans-Canada
Longueuil, Quebec
J4G 2P9

Tel: (514) 598-8750
Fax: (514) 598-1578

Sean Power
President
STEELCOR INDUSTRIES INC.
P.O. Box 208
Buchans, NF
A0H 1G0

Tel: (709) 672-3351
Fax: (709) 672-3564

Tom Morse
Marketing Manager
STORK CANADA
47 Marie Victorin Blvd.
Quebec
J5R 1B6

Tel: (514) 659-6571
Fax: (514) 659-1035

Lars Henriksson
Deputy Trade
Commissioner
SWEDISH TRADE COUNCIL
One Queen Street East
Suite 2010
P.O. Box 86
Toronto, Ontario
M5C 2W5

Tel: (416) 367-8152
Fax: (416) 367-8639

Sid Sheps
TECHNOVATION GROUP
223 Duckworth Street
St. John's, NF
A1C 1G8

Tel: (709) 739-5039
Fax: (709) 738-3853

Majda Vucko
Technical Sales
Representative
TI TITANIUM LTD.
5055 Rue Levy
Ville St. Laurent
Quebec
H4R 2N9

Tel: (514) 334-5781
Fax: (514) 334-3410

Raymond Lavoine
Manager
TMP OFFSHORE OIL INC.
Suite 790, Cabot Place
100 New Gower Street
St. John's, NF
A1C 6K3

Tel: (709) 754-4715
Fax: (709) 754-4704

Reuben Goldman
TOPSIDE CONTRACTORS
OF NFLD/MCDERMOTT
INTERNATIONAL
P.O. Box 5680
St. John's, NF
A1C 5W8

Tel: (709) 579-2010
Fax: (709) 726-0806

Mike Cote
TOPSIDE CONTRACTORS
OF NFLD/DOMINION
BRIDGE-QUEBEC
P.O. Box 5680
St. John's, NF
A1C 5V3

Tel: (709) 579-2010
Fax: (709) 726-0806

William Mahler
TOPSIDE CONTRACTORS
OF NEWFOUNDLAND
P.O. Box 5680
St. John's, NF
A1C 5W8

Tel: (709) 579-2010
Fax: (709) 726-0806

Roger Flood
TOPSIDE CONTRACTORS
OF NEWFOUNDLAND
P.O. Box 5680
St. John's, NF
A1C 5W8

Tel: (709) 579-2010
Fax: (709) 726-0806

Allan Maltby
Manager - Advanced
Manufacturing
TRENTON WORKS LAVALIN
INC.
P.O. Box 130
Main Street
Trenton, NS
B0K 1X0

Tel: (902) 752-1541
Fax: (902) 752-6648

Gary Mingo
TRENTON WORKS LAVALIN
INC.
P.O. Box 130
Main Street
Trenton, NS
B0K 1X0

Tel: (902) 752-1541
Fax: (902) 752-6648

Brad Murray
TRENTON WORKS LAVALIN
INC.
P.O. Box 130
Main Street
St. John's, NF
B0K 1X0

Tel: (902) 752-1541
Fax: (902) 752-6648

Harvey Attra
U.S. DEPT. OF ENERGY
17 Lord's Highway
Weston CT
06883

Tel: (202) 586-0151
Fax: (202) 586-3047

Luke Reynolds
Specialist-Major Acounts
ULTRAMAR CANADA
P.O. Box 8820
39 Pippy Place
St. John's, NF
A1B 4K5

Tel: (709) 726-9662
Fax: (709) 570-1164

Gary Moore
Technical Services Sales
Representatives
VICTAULIC CO. OF
CANADA LTD.
65 Worcester Road
Rexdale, Ontario
M9W 5N7

Tel: (416) 675-5575
Fax: (416) 675-5729

Uruj Kirmani
Energy Specialist
WORLD BANK
1818H Street NW
Washington, DC
20433

Tel: (202) 458-2892